INTER-UNIVERSITY COUNCIL FOR EAST AFRICA

BENCHMARKS FOR

CIVIL, MECHANICAL, ELECTRICAL, ELECTRONICS AND TELECOMMUNICATION, AGRICULTURAL

ENGINEERING PROGRAMMES

DRAFT

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ACRONYMS

ABET	Accreditation Board for Engineering and Technology
ASEE	American Society of Engineering Education
AC	Alternating Current
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CAD/CAM	Computer-Aided Design/Computer-Aided Manufacturing
CATS	Credit Accumulation and Transfer system
CCITT	Consultative Committee for International Telephony and Telegraphy
CIM	Computer Integrated Manufacturing
DAAD	German Academic Exchange Services
DC	Direct Current
EA	Environmental Audit
EAC	East African Community
EAQFHE	East African Qualifications Framework for Higher Education
ECT	Electric Circuit Theory
ECTS	European Credit Transfer System
EIA	Environmental Impact Assessment
ELOs	Expected Learning Outcomes
EMF	Electromagnetic Fields
ENG.	Engineer
ESIA	Environmental and Social Impact Assessment
EQF	European Qualifications Framework
GIS	Geographic Information System
HEC	Higher Education Council
HEIs	Higher Education Institutions
HIV/AIDS	Human Immunodeficiency Virus /Acquired Immune Deficiency Syndrome
HRK	German Rectors Conference
IC	Integrated Circuits

ICT	Information and Communication Technology
IEK	Institution of Engineers Kenya
IER	Institution of Engineers Rwanda
IoT	Internet of Things
IUCEA	Inter-University Council for East Africa
MATLAB	Matrix Laboratory
NQFs	National Qualifications Frameworks
NRAs	Higher Education National Regulatory Agencies
PCB	Printed Circuit Board
PLC	PowerLine Communication
QA	Quality Assurance
QAA	Quality Assurance Agency for Higher Education, UK
QM	Quality Management
RS	Remote Sensing
TCU	Tanzania Commission for Universities
UDSM	University of Dar es Salaam
UIPE	Uganda Institution of Professional Engineers
ULSI	Ultra Large Scale Integration
WPT	Wireless Power Transmission

GLOSSARY[1]

Analytical and Communication Skills	The ability to use basic mathematical and statistical techniques, communicate effectively in oral and written form, and use Information and Communications Technology.
Attitude	Attitude means a settled way of thinking or feeling about something. *It comprises four major components i.e. affective (emotions or feelings), Cognitive (belief or opinions held consciously), Conative (inclination for action) and Evaluative (positive or negative response to stimuli).*
Bachelor's degree	An undergraduate academic degree awarded by a HEI upon completion of a course of study lasting a length of period dependent on the academic discipline and institution. *For the degree, the holder of the qualification will be able to apply knowledge, skills and understanding in a wide and unpredictable variety of contexts with substantial personal responsibility, responsibility for the work of others and responsibility for the allocation of resources, policy, planning, execution and evaluation.*
Basic phase	The first phase of a bachelor's degree programme in a specified field of engineering, common and compulsory for all learners and consisting of core and supportive courses.
Benchmark	Point of reference against which something may be measured.
Benchmark Standards	Subject benchmark statements set out expectations about standards of degrees in a range of subject areas/fields. They describe what gives a discipline its coherence and identity, and define what can be expected of a graduate in terms of the abilities and skills needed to develop understanding or competence in the subject. (T)
Cognitive skills	The ability to apply knowledge and understanding of concepts, principles, theories and procedures when asked to do so; and analyse situations and apply conceptual understanding of principles and theories in critical thinking and creative problem solving when faced with unanticipated new situations.
Competence	The proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development (according to EQF). *Is a product of individual characteristics and achieved learning outcomes. They include relevant skills that may be acquired outs a programme's formal teaching and learning environment and be augmented by a learner's natural abilities and experiences.*
Core courses	These are 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 learner.
Supportive courses	These are those that back up the core courses; without these courses it will be difficult to understand the core courses such as "mathematics" and

[1] Use is made from the Tuning glossary in Tuning, A Guide to Formulating Degree Programme Profiles, Bilbao/The Hague, 2010 (Chapter 3, page 51-57). The descriptions of Tuning are marked with (T). EAQFHE (2015) also provides details of higher education terminology and requirements for the EAC which is now a single higher education area.

	"Fundamentals of ICT." These courses are compulsory for all learners.
Elective courses	These are those that can be taken by a learner to deepen or broaden their knowledge. The courses are not compulsory; however, a learner has to make a choice to meet the minimum credit requirements for graduation.
Engineering	Engineering refers to the creative application of scientific principles to design or develop structures, machines, apparatus or manufacturing processes or works utilising them singly or in combination or to construct or operate the same with full cognisance of their design or to forecast their behaviour under specific operating conditions or aspects of intended functions, economics of operation and safety to life and property.
Course/Unit	A self-contained, formally structured learning experience. It should have a coherent and explicit set of learning outcomes and appropriate assessment criteria. Course /units can have different numbers of credits.
Credit	Credit is awarded to a learner in recognition of the verified achievement of designated learning outcomes at a specified level. The credit unit shall be based on 10 notional hours of learning, knowing that some learners shall take more and some less time. For learners credit provides a tool for describing and comparing learning in terms of volume and intellectual demand and can therefore assist learners in planning and accumulating learning towards an award. Credit can also help in transfer between institutions (both nationally and internationally) if learners wish or need to interrupt their studies or move. *See EAQFHE for details.*
Curriculum Alignment Matrix	An instrument for checking the contribution of a course, unit or module to the achievement of the programme learning outcomes.
Curriculum	See programme
Doctorate	It is a Degree at postgraduate study level which qualifies individuals who apply a substantial body of knowledge to research, investigate and develop new knowledge, in one or more fields of investigation, scholarship or professional practice. See EAQFHE for details on qualifications at different levels of HE study.
Equivalency	Having the same value, without being uniform.
Field Specific Learning Outcomes	The Learning outcomes that are typical for a specific engineering field or course/module. *See also generic learning outcomes*
Generic Learning Outcomes	These Are those learning outcomes, expected from all academic trained graduates, irrespective of the study programme. Examples of generic learning outcomes are problem solving, communication skills, and ability to cooperate.
Harmonisation	Harmonisation of programmes means that the programmes in the region are comparable based on agreed benchmarks formulated within the IUCEA

	framework.
Higher Education	Higher Education (HE) primarily describes post-secondary learning that takes place at universities, as well as other colleges and institutions that award degrees, professional qualifications and continuing professional development modules. *Whilst HE is the common name in the East Africa, it is also known as post-secondary, tertiary and third level education. The right of access to higher education is enshrined in both UN Conventions and EAC Partner State Constitutions.*
Internship	Is a period of supervised training *at the workplace* and is an important part of the programme. It offers the student the opportunity to become acquainted with their future job. It provides the student with experiences at working floor level.
Knowledge	Is the body of facts, principles, theories and practices that is related to a field of work or study. It is the outcome of the assimilation of information through learning and is described as theoretical and/or factual.
Learning outcomes	Statement of what a learner is expected to know, understand and/or be able to demonstrate after completion of a process of learning. *Learning outcomes are linked to the relevant level and since they should generally be assessable they should be written in terms of how the learning is represented.*
Master's degree	It is a degree at postgraduate study level in which the holder of the qualification will be able to display mastery of a complex and specialised area of knowledge and skills, employing knowledge and understanding to conduct research or advanced technical or professional activity, able to work autonomously and in complex and unpredictable situations.
Module/Unit	Self-contained, formally structured, learning experience with a coherent and explicit set of learning outcomes and assessment criteria.
Module description	Module description is statement of the aims, objectives/learning outcomes, content, learning and teaching processes, mode of assessment of students and learning resources applicable to a block of study.
National Qualification Framework (NQF)	The policy framework that defines all qualifications recognized nationally in post-compulsory education and training within a country. The NQF comprises titles and guidelines, which define each qualification, together with principles and protocols covering articulation and issuance of qualifications, and Statements of Attainment. *See also Qualifications framework.*
Programme	A set of coherent educational components, based on learning outcomes, that are recognised for the award of a specific qualification through the accumulation of a specified number of credits and the development of specified competences.(T)
Programme Objectives	Overall specification of the intention or purpose of a programme of study. (T)
Project work	Is a form of study, which is problem oriented. The project is normally based on an actual existing problem, which may be linked to internship and leads to possible solutions. The project may be practical or research oriented.

Qualifications Framework	An instrument for the development and classification of qualifications according to a set of criteria for levels of learning and skills and competences achieved.
Skills	Skills mean the ability to apply knowledge and use know-how to complete tasks and solve problems. *Skills are categorised as: Cognitive skills (involving the use of logical, intuitive and creative thinking); practical skills (involving manual dexterity and the use of methods, materials, tools and instruments); Interpersonal skills (the way of communication, cooperation, e.t.c).*
Shared phase	Shared phase of a bachelor's degree programme in different fields of engineering; during the early stage of study during which courses common to different fields of engineering are undertaken. Courses undertaken during the shared phase consists of core and supportive courses undertaken in the initial and advanced stages of the programmes, and are incorporated in the basic phase of the programme of a specific engineering field of study.
Specialisation phase	The phase of a bachelor's degree programme, after the basic phase, in a specified field of engineering, which allows learners to choose applicable specialisations in line with their interests in the engineering field of study.
Standards	Explicit levels of academic attainment, which are used to describe and measure academic requirements and achievements of individual learners and groups of learners.
Subject area	Learning experience in field of engineering or other area of knowledge; reflected in a course / module / unit *(see course/unit or module/unit)*. Minimum courses highlighted in these benchmarks are ideally indicated in terms of subject areas.
Tuning	Tuning Is a collaborative, consultative process involving academics working in subject groups with employers and other stakeholders in curriculum development to enhance student competences. Tuning projects which are funded by the European Commission in higher education have been successfully completed in over sixty countries around the world. *In Africa there is Tuning Africa which is a network of intercultural interconnected communities of academics who reflect, debate and elaborate instruments and share the around a discipline or theme in the conscious context of building mutual trust and confidence (see www.tuningafrica.org).*

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FOREWORD

The Inter-University Council for East Africa (IUCEA) is a strategic institution of the East African Community (EAC) responsible for the development and coordination of higher education and research in the region. The EAC considers higher education as critical for the attainment of socio-economic development and regional integration. As such, after having been recognised as the surviving institution of the former Community responsible for coordinating the networking of university institutions in the region, IUCEA has assumed a broader role as a building block for the achievement of sustainable socio-economic development and regional integration. In that regard, the mission of IUCEA now focuses on the promotion of strategic and sustainable development of higher education systems and research for supporting East Africa's socio-economic development and regional integration. The IUCEA has set its vision to become a strategic institution of the East African Community responsible for promoting, developing and coordinating human resources development and research in the region.

Hence, in 2006 IUCEA initiated a process aimed at harmonising regional quality assurance by establishing a common East African quality assurance framework, regional quality assurance office at the IUCEA Secretariat, and setting regional higher education benchmarks quality standards based on internationally recognised frameworks. The process would also prepare a user-friendly quality assurance handbook based on existing national benchmarks and systems, and streamline national and institutional quality assurance systems according to the local perspectives with the aim of promoting international competitiveness of universities in East Africa.

The initiative also focused on capacity building through providing appropriate training on the implementation of the quality assurance system to staff in universities and national commissions and councils for higher education in the Partner States. It is linked to the establishment of a regional qualifications framework. It was anticipated that the regional qualifications framework would facilitate harmonization of education and training systems, and qualifications thereby clearly indicating the programme learning outcomes, the different qualification levels, credit system and recognition of prior learning, among others. Therefore, the framework would easily facilitate mutual recognition of qualifications across the region as envisioned in the EAC Common Market Protocol. All these interventions contributed significantly in transforming East African Community into a Common Higher Education Area, a Declaration that was made by the 18th Summit of the EAC Heads of State on 20th May 2017.

In developing the regional quality assurance system in higher education in East Africa, IUCEA in collaboration with the German Academic Exchange Service (DAAD) and the Germany Rectors' Conference (HRK) within the framework of their joint Higher Education Management support programme referred to as "Dialogue on Innovative Higher Education Strategies (DIES)", started to work on this initiative through a consultative process involving various stakeholders of higher education in the region. The process involved a number of consultative meetings and workshops at country and regional level, aimed at building consensus and mapping out a strategy on how to establish a regional quality assurance framework. This included the development of an operational tool in the form of a Quality Assurance Handbook. The consultative forums were also aimed at ensuring that all performance indicators and quality benchmarks were agreed upon and owned by all end-user institutions. Additionally, IUCEA intended to develop specific subjects' benchmarks as part of the tools for harmonisation purposed academic programmes taught in higher education institutions in the region in addition to the development of The Handbook *A Roadmap to Quality*. The first benchmarks were formulated for Bachelor of Business Related Studies. The second set of benchmarks was for the Bachelor of Computer Science and Bachelor of Information Technology and subsequently, the Benchmarks for Education Programmes. The third set of benchmarks was for the medicine and dentistry, agriculture and engineering disciplines. The current publication contains Benchmarks for the bachelor's degree in Civil Engineering, Mechanical Engineering, Electrical Engineering, Electronics and Telecommunication Engineering, and Agricultural Engineering.

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On behalf of the IUCEA secretariat, it is my sincere hope and expectation that the higher education fraternity in the region will make use of these benchmarks in all educational processes and world of work to ensure that our programmes are relevant and of expected quality.

Prof. Alexandre Lyambabaje **Kampala, June 2019**
IUCEA, Executive Secretary

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The National Commissions / Councils of Higher Education of the EAC Partner States are highly acknowledged for their instrumental contribution in spearheading and coordinating the processes in the development of these benchmarks in their respective countries. The staff representing these institutions to this process are sincerely appreciated for their dedication and inputs to this exercise. It is my expectation that these benchmarks will provide an important building block of harmonisation of education as part of operationalization of the East African Community Common Higher Education Area and therefore all stakeholders will use them in the various intended purposes such as curriculum development and review, assessing graduates' competences, and comparability, among others.

Prof. Alexandre Lyambabaje **Kampala, June 2019**
IUCEA, Executive Secretary

PREAMBLE

The benchmarks for the bachelor's degree in the five selected fields of engineering (i.e. civil engineering, mechanical engineering, electrical engineering, electronics and telecommunication engineering, and agricultural engineering) contained herein have been developed as one of the set milestones for the development of an East African Quality Assurance System that is being operationalised as one of the regional strategies for harmonisation of higher education system, within the EAC integration agenda. The system constitutes the framework of the East African Common Higher Education Area. Benchmarks for the bachelor's degree in above engineering fields have been developed in full consciousness that the programmes are different across HEIs in the EAC partner states and therefore need review in light of the developed benchmarks.

As highlighted in the foreword, the benchmarks are aimed at providing an important process of harmonisation of the training for the bachelor's degree in the five selected engineering fields and should be beneficial to all the players in higher education common area in the EAC partner states. Thus, the main objective of benchmarking is to provide a baseline for comparability of the bachelor's degree in the above engineering fields and their graduates within and outside the EAC by harmonising practice in the region. However, the benchmarks do not constitute a checklist for programme curriculum developers. They are to be used as a yardstick or a point of reference, and not as absolute standards.

This document has been structured into four parts, outlined as follows:

- **Part 1** is the introduction. It presents the background, objectives and the justification. It also articulates the development process of the benchmarks and how they were formulated;
- **Part 2** is on the use of the benchmarks. It shows the relation between the benchmarks and the regional qualifications frameworks, the curriculum and the link with quality assurance;
- **Part 3** presents the generic benchmarks for a bachelor's degree in engineering; highlighting what is common to the five selected engineering fields; and

Part 4 presents the benchmarks for a bachelor's degree in engineering specific to each of the five selected engineering fields i.e. civil engineering, mechanical engineering, electrical engineering, electronics and telecommunication engineering, and agricultural engineering.

PART 1: INTRODUCTION

1.1 Background

One of the mandates of the Inter-University Council for East Africa (IUCEA) is to maintain high and comparable academic standards in higher education regionally and internationally, with special emphasis on the promotion of Quality Assurance (QA) and Quality Management (QM). In that regard, IUCEA aspires to operate within the expectations of stakeholders to deliver services that enhance and harness QA in the region. In East Africa, the notion of QA in higher education is an issue of great concern among all stakeholders, including policy makers, parents, employers, and students. A number of factors have contributed to this phenomenon. East Africa has experienced rapid expansion of the number and enrolment levels in higher learning institutions in recent times. This has been triggered by the exponential increase in demand of access to higher education in each of the countries in the region. As a result, the IUCEA felt the need to ensure that the rapid expansion of higher education in the region did not compromise quality of the very education being delivered. Furthermore, in recent years student mobility within East Africa has increased tremendously, necessitating the need to institute mechanisms for comparability of the quality of education in universities in East Africa.

It is important to note that education has become a tradable commodity across borders and hence there have been efforts to institute international safeguards that would ensure maintenance of international quality standards. These efforts are being implemented within regional and international QA frameworks. The development of the benchmarks therefore became a necessity. The formulated regional benchmarks focused on the Engineering Programmes.

1.2 Objectives of the Formulated Benchmarks

1.2.1 WORKING DEFINITION OF ENGINEERING

Engineering refers to the creative application of scientific principles to design or develop structures, machines, apparatus or manufacturing processes or works utilising them singly or in combination or to construct or operate the same with full cognisance of their design or to forecast their behaviour under specific operating conditions or aspects of intended functions, economics of operation and safety to life and property.[2]

1.2.2 CRITERIA FOR SELECTION OF ENGINEERING FIELDS FOR BENCHMARKING

A situational analysis indicated that they are numerous programmes and nomenclature in engineering. Because of the difficulty in benchmarking each of the programmes, the following criteria were used for selection of the disciplines for benchmarking:

- Traditional engineering disciplines;
- Programmes that are conventionally offered for relevance to regional economies and needs usually constituting standalone degree programmes;
- Specialisation programmes of traditional fields to be included within the main fields;
- Traditional programmes that offer elements of specialisations/branches as electives; and
- The specialisations justified for offer as emerging in light of the regional economies.

1.2.3 SELECTED ENGINEERING FIELDS

Based on the criteria used above, the following were identified as major engineering programmes:

- Civil Engineering;
- Mechanical Engineering;
- Electrical Engineering;
- Electronics and Telecommunication Engineering;
- Agricultural Engineering;
- Chemical and Process Engineering;
- Geomatic Engineering; and
- Petroleum Engineering.

1.2.4 JUSTIFICATION

Following its revitalisation and subsequent ratification of the Protocol in 2002, IUCEA initiated a reform process aimed at re-positioning itself in order to address its expanded mandate within the Community. Such reforms became necessary after the enactment of the IUCEA Act in 2009. The reforms prompted the need to establish an appropriate environment for harmonisation of higher

[2] As defined in the Mutual Recognition Agreement (MRA) between competent authorities of engineering professions in the East African Community (EAC) signed on the 7th of December 2012 by the respective registrars from the Engineering Registration Boards of partner states.

education systems, so as to promote the EAC regional integration agenda as envisioned in the Common Market Protocol. Among the important steps towards harmonization of higher education in the region was the setting up of a regional quality assurance system for universities that was initiated in 2006.

In light of the above regional dynamics, it was deemed necessary to develop the benchmarks that would then be used within the institutions in the region. In the process of establishing the regional Quality Assurance system, the IUCEA piloted a QA handbook by subjecting selected academic programmes to internal and external review. It was on the basis of analysis of peer review reports of all the academic programmes piloted by IUCEA that benchmarks for engineering programmes alongside those of Medicine and Agriculture have been developed.

1.3 The Development Process

The development of the benchmarks for the Engineering programmes went through a number of iterative processes that included data collection, analysis, and documentation on the basis of which consultative meetings bringing together multiple stakeholders in various developmental stages as follows:

- ***Preparatory Meeting held in Nairobi, Kenya on 15th - 17th March 2017***

A preparatory meeting on developing benchmarks for engineering programmes in East Africa was held on 15-17 March 2017 at the Intercontinental Hotel, Nairobi, Kenya. It was agreed during this meeting that the benchmarks would be generic and applicable for anyone in an East African higher education institution developing a Bachelor of Engineering programme in any field. The meeting also identified focus areas for the Bachelor of Engineering benchmarks would focus on programme goal, programme objectives, programme expected learning outcomes, translating the learning outcomes into the programme, the learning outcomes and the curriculum alignment matrix, course/module description and the role of internship and project work. The specific activities carried out during this meeting are as follows:

- ✓ Country presentations by National Councils / Commissions on national perspective of the status of Engineering Programmes in East Africa
- ✓ An induction on the rationale and procedures for development of benchmarks
- ✓ Preparation of a work plan and milestones

- ✓ Development of frame of reference for engineering programmes to articulate graduate attributes that cut across fields for engineers and specified required knowledge.

- ***Benchmarks Development Meeting held in Kampala, Uganda on 10th - 12th July 2017***

Actual development of benchmarks for engineering programmes was enhanced. Main activities carried out included the following:

- ✓ Development of generic learning outcomes for the engineering field and specific learning outcomes for programmes in the various disciplines,
- ✓ Development of minimum courses for each programme, and
- ✓ Alignment of learning outcomes with courses.

- ***The 3rd meeting held in Kampala, Uganda on 27th - 29th November 2017***

Development of benchmarks continued, with emphasis on the following engineering programmes: civil engineering, mechanical engineering, electrical engineering and electronics and telecommunication engineering.

- ***The 4th meeting held in Nairobi, Kenya on 18th – 20th March 2019***

Further development of benchmarks was undertaken, with emphasis on the following engineering programmes: civil engineering, mechanical engineering, electrical engineering, agricultural engineering, and electronics and telecommunication engineering.

- ***The 5th meeting held in Kampala, on 24th – 26th April 2019***

Finalisation of the benchmarks for five selected engineering fields (i.e. civil engineering, mechanical engineering, electrical engineering, agricultural engineering, and electronics and telecommunication engineering) as well as editing of the draft document was undertaken. The draft document was then validated (by electronic circulation) by various stakeholders (including National Councils/Commissions for Higher Education, Professional bodies and HEIs in EAC partner states that offer engineering programmes).

1.4 Stakeholders Involvement

Efforts were made to involve key stakeholders including higher education experts, professional bodies, employers and industry. Therefore, participants were drawn from, academic units for engineering from represented HEIs, National Councils/Commissions for Higher Education, professional bodies, employers and industry representatives from EAC Partner States. Indeed, professional bodies and National Commissions and Councils participated throughout the benchmarking process and therefore these benchmarks are an outcome of joint effort between them and IUCEA.

1.5 Engineering Practice

A practising engineer typically holds a degree in the engineering field of engagement. Practising engineers should be members of engineering professional bodies in the EAC partner state of practice; for example, the Institution of Engineers of Kenya (IEK), the Institution of Engineers Tanzania (IET), Uganda Institution of Professional Engineers (UIPE), The Institution of Engineers Rwanda (IER), and the bodies that bring together engineering professionals in the Republic of South Sudan and Burundi. Member countries require practicing engineers to have professional certification/registration as per the requirements of the respective professional regulatory body in the EAC partner state of practice. The institutions in the partner states are developing protocols for mutual recognition. Hence, these benchmarks will help to ensure that the academic qualifications are comparable as a basis for free movement of labour and goods across the boundaries of the countries.

PART 2: THE USE OF BENCHMARKS

2.1 The Benchmarks and the Qualifications Framework

As earlier mentioned, this document is not meant to replace the initiatives of the EAC Partner States and institutions, but rather to provide a regional benchmark with regard to the learning outcomes. Therefore, care has been taken to ensure that the benchmarks are in line with the various National Qualification Frameworks (NQFs). Globally, within the last one to two decades, there have been developments in which various countries have either formulated or are formulating a NQF. Such National Qualifications Framework may be regarded as the policy framework that defines all qualifications recognized nationally in post-compulsory education and training within a country. The NQFs within the EAC Partner States' comprise titles of qualifications offered and guidelines which define each qualification together with principles and protocols covering articulation and issuance of qualifications, and Statements of Attainment.

For example the NQF of Tanzania[3] defines National Qualifications Framework (NQF) as *"a national instrument for the development and classification of qualifications according to a set of criteria for levels of learning and skills achieved."* The East African Qualifications framework[4] 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 competences achieved.*"

Looking at the NQFs in Europe and the European Qualifications framework, and other NQFs in other parts of the world, it is clear they are as an effort to describe the different levels of education. Concerning Higher Education, 3 levels are described: Bachelor's, Master's and Doctorate. For the purpose of this document, benchmarks for only bachelor's degrees are provided. The level number or duration of bachelor's degrees within the EAC Partners States with their NQFs may differ. In the European Qualification frameworks, it is level 6 and 7 whereas in the EAQFHE it is level 8 and 9; however, the level descriptors are more or less the same. HEIs in the EAC partner states developing curricula for engineering programmes in the different fields should ensure observance of the requirements of the EAQFHE; in as far as the credit weighting of courses / units is concerned.

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[3] The Tanzanian Commission for universities, *National Qualification framework*, final draft, March 2010

[4] IUCEA, *The East African Qualifications Framework*, May 2015

- *Bachelor's Degree (Level 8)*

The holder of the qualification will be able to apply knowledge, skills and understanding in a wide and unpredictable variety of contexts with substantial personal responsibility for the work of others and responsibility for the allocation of resources, policy, planning, execution and evaluation. The description of the Bachelors level in NQFs is very general. Clearly, in order to be operationalised, the level has to be filled in and elaborated with statements of learning outcomes.

In most of the NQFs, the level descriptors are elaborated in more detailed generic learning outcomes. Each programme has to interpret the generic learning outcomes into specific course units within specific subjects For example, one of the generic learning outcomes is ability to identify, pose and solve problems. This might become achieved through operationalisation of research concepts and techniques to solve engineering problems or to solve emerging challenges in higher education institutions delivering programmes in engineering fields.

2.2 The Benchmarks and Curriculum Design

The formulated benchmarks, as outlined below, are a good starting point in the development or reviewing of the bachelor's degree programmes for the five selected engineering fields in the EAC partner states.

2.2. 1 PROGRAMME OBJECTIVES

The Bachelor of Engineering benchmarks should be designed in such a way that they address the concerns of different stakeholders. This should be reflected in the programme objectives. These objectives can be grouped into three categories:

- Academic ability
- Employability
- Personal development

There consultation[5] process to develop these benchmarks, overall, indicated the need to have harmonised minimum expected learning outcomes within the EAC partner states for bachelor's degree programmes in engineering and the specific engineering Fields in the current Benchmarks.

[5] The consultation was with, among others, regional experts from the Professional bodies, Industry, Academic and National regulatory Agencies for Higher Education within the EAC Partners States.

2.2. 2 FORMULATING THE EXPECTED LEARNING OUTCOMES

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 the whole programme, a module or a course. HEIs are expected to compare their already formulated learning outcomes with the benchmarks and see what is missing or what should be rephrased. For each learning outcome, one should describe how the outcome would be measured and assessed. It is worth noting that benchmarks are based on the formulated learning outcomes.

According to literature on benchmarking and learning outcomes, there are many different definitions of learning outcomes or competences. In the European Qualification framework (EQF)[6] *Learning outcomes* are defined as: statements of what a learner knows, understands and is able to do on completion of a learning process, which are defined in terms of knowledge, skills and competence. *Competence,* according to EQF, is the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development. According to IUCEA[7] learning outcomes are viewed as what a learner is expected to know and understand, and be able to do or demonstrate, on completion of a learning process within a recognised qualifications framework.

In the discussion about learning outcomes, the concept *Competences* also keeps coming up. Although the notion Competence is used regularly, it is not always clear what competences are. In all the definitions there is a hint to knowledge, applying knowledge and skills. Furthermore, there is talk about abilities and attitudes. It seems that *Competences* at this moment connotes learning outcomes and more. It includes relevant skills that may be acquired outs a programme's formal teaching and learning environment and be augmented by a learner's natural abilities and experiences. In short, learning outcomes are not to be equated to competences but the two are not mutually exclusive. A graduate exhibiting competences at a working place will have partly acquired the skills as outcomes of their study. But parts of the competences have to do with in-born characteristics.

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[6] *The European Qualification Framework for Life Long Learning, European Commission,* 2008

[7] IUCEA*, The East African Qualifications Framework,* May 2015

As earlier mentioned, however, a learning outcome is a statement of the knowledge, skills and attitudes students should have acquired at the end of each course (module, unit) and programme. It has been observed that although universities are engaged in the practice of defining objectives and measuring outcomes in one form or another, many do not approach the process of formulating learning outcomes in a uniform and collaborative way. It is important to note that focusing on and defining learning outcomes would create an opportunity to:

- Enhance students' learning and mobility;
- Provide guidance to instructors;
- Identify and overcome barriers to effective teaching;
- Facilitate collaboration among HEIs in the region and beyond;
- Improve students' learning, retention and completion;
- Produce quality graduates; and
- Increase students' chances for employability.

In this document, the following definition for Learning Outcomes is used:

Learning outcomes: statements of the knowledge, skills and attitude that a learner is able to demonstrate on completion of a learning process.

Based on Bloom's taxonomy learning outcomes can be divided into:

- *Knowledge*

Knowledge means the outcome of the assimilation of information through learning. Knowledge is the body of facts, principles, theories and practices that is related to a field of work or study. Knowledge is described as theoretical and/or factual.

- *Skills*

Skills mean the ability to apply knowledge and use know-how to complete tasks and solve problems. Skills are categorised as:

- ✓ *Cognitive skills* (involving the use of logical, intuitive and creative thinking);
- ✓ *Practical skills* (involving manual dexterity and the use of methods, materials, tools and instruments); and
- ✓ *Interpersonal skills* (the way of communication, cooperation, e.t.c).

- *Attitude*

Attitude means a settled way of thinking or feeling about something. Four major components of attitude are: affective (emotions or feelings), Cognitive (belief or opinions held consciously), Conative (inclination for action), Evaluative (positive or negative response to stimuli). The following Figure 2.1 shows the relationships between knowledge, skills and attitude. The model is also used to categorise the learning outcomes for Engineering.

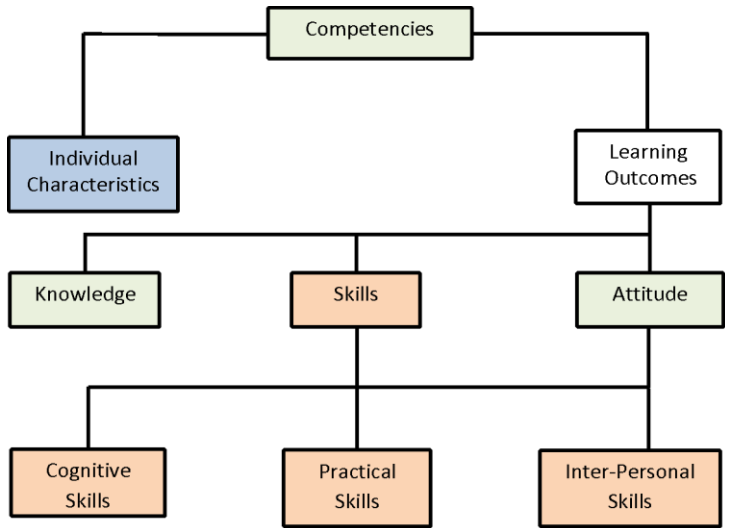

Figure 2.1: Categorisation of Learning Outcomes

In formulating learning outcomes, a distinction has to be made between *generic* learning outcomes and *field specific* learning outcomes. Generic learning outcomes are those outcomes expected from all academic trained graduates. Examples of generic learning outcomes are: problem solving, communication skills, and ability to cooperate. A key characteristic of the generic learning outcomes is that they are applicable to a variety of disciplines rather than only in specific fields. Subject specific learning outcomes are those that are typical to that discipline.

2.2. 3 TRANSLATING LEARNING OUTCOMES INTO THE PROGRAMME

The next step in the process after the formulation of learning outcomes is to identify what courses are needed to achieve the learning outcomes. Thereafter a distinction has to be made between the core courses and the supportive courses, and establish what is already present in the programme and then what courses should be added. To check if the planned courses cover the learning outcomes, it is important to develop a curriculum alignment matrix as shown in Table 2.1 below. Each course and its learning outcomes must be developed such that they contribute to the programme's learning outcomes. It is worth noting that in Part 3 and Part 4 of this document, subject areas are indicated within the required minimum courses; implying that multiple subject areas may be covered in a course / module / unit.

Table 2.1: Curriculum Alignment Matrix

Bachelor's degree programme, engineering					
Learning outcomes	*Course 1*	*Course 2*	*Course 3*	*Course 4*	*Course 5*
Communication skills	x		X		
Critical thinking		X		x	x
Problem solving					x
Cooperate/working together	x				
e.t.c					

2.2. 4 THE BENCHMARKS AND DEVELOPMENT OF COURSES

In this document, the learning outcomes for the engineering discipline and for the different engineering fields provided. Higher Education Institutions (HEIs) will have to develop the modules or course units, starting with the formulation of the learning outcomes for specific modules or course units. An essential part of the programme is to assess how far the student has achieved the learning outcomes. Therefore, it is necessary for the HEIs to decide how each learning outcome will be assessed. There should be ensurance, during programme curriculum design, for sufficient coverage of requisite, pre-requisites and co-requisite courses.

2.3 The Benchmarks and Quality Assurance

It is envisaged that the benchmarks will play a significant role in quality assurance of their respective programmes. Although each National Regulatory Agency (NRA) applies its own criteria in assessing the quality of programmes, the benchmarks can play a significant role in harmonisation of quality assessment and quality assurance in the region. It is therefore expected that the NRAs will ideally align their standards with these benchmarks. The benchmarks also offer external assessment terms a frame of reference in assessing the quality of a programme. For the

HEI, the benchmarks offer a good instrument for evaluating the quality of their own programmes.

2.4 Implementation of the Benchmarks

The implementation of these benchmarks is the responsibility of HEIs and the oversight responsibility is that of the National Regulatory Agencies. IUCEA will provide the overall coordination and evaluation of the use and implementation of the Benchmarks in partnership with the National Regulatory Agencies for Higher Education.

2.5 Review of the Benchmarks

These benchmarks will be subject to review after every five year period to take care of emerging trends in the environment as well as feedback from use and implementation of the benchmarks.

PART 3: GENERIC BENCHMARKS FOR A BACHELOR'S IN ENGINEERING PROGRAMME

3. 1 Description of Engineering[8,9]

Engineering deals with the provision of practical solutions to problems; ensuring socio-economic and technological progress in our ever changing world. It involves the conception, design, provision / construction, operation, maintenance, commissioning, decommissioning, disposal and recycling of infrastructure, products, processes and systems; with the engineers efficiently and economically applying scientific, mathematical, economic and social knowledge, understanding, skills, know-how and experience within the limitations imposed by environmental, cultural, manufacturability, social, legal and economic conditions, among others.

Engineering is reliant on three cores of scientific principles, mathematics and realisation. Scientific principles underlie engineering applications, realisation involves the creative and innovative abilities; to conceive, develop and actualise what was non-existent (infrastructure, products, processes, systems e.t.c) relating invention / innovation with social and commercial value. The creativity and innovation abilities for formulation of efficient, economic, ethical and sustainable practical solutions are vital to engineering distinguishing it from science and are shared across multiple traditional and contemporary subjects (including civil, mechanical, electrical, electronics and telecommunication, agricultural, geomatics, chemical and process, and petroleum engineering herein).

3. 2 Goal of Bachelor's in Engineering Programme

The goal of an engineering programme is to produce an engineering graduate capable of applying scientific, mathematical, economic and social knowledge, understanding, skills, know-how and experience in the conception, design, construction / provision, manufacture, commissioning, operation, maintenance, decommissioning, disposal and recycling of infrastructure / structures, products / machines, processes and systems in an efficient and economic manner; as applicable to the specific field of engineering (herein the five selected i.e. civil, mechanical, electrical, electronics and telecommunication, and agricultural).

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

[9] ABET

3. 3 Frame of Reference for the Engineering Discipline

3.3.1 OBJECTIVES

The objective of developing a frame of reference was to articulate the engineering graduate attributes that cut across engineering fields of the discipline, and specified required knowledge to inform the learning outcomes and the constituent components of curriculum design for different engineering fields' programmes.

3.3.2 ENGINEERING GRADUATE ATTRIBUTES[10, 11]

An engineering graduate possesses the following attributes:

i. **Communicate Effectively**

a) Technical communication through reports, drawings and specifications

b) Digital literacy in design, drawings production, report writing, and presentation

ii. **Execution of Engineering Projects**

a) Must be able to supervise / oversee the execution of Engineering projects

b) Understand production / fabrication procedures

iii. **Flexibility**

Self-confident to innovate by developing sustainable solutions in changing circumstances through critical thinking and creativity, independently or in collaboration with others.

iv. **Requisite Basic Knowledge**

Possess fundamental engineering science, mathematics, political and socio-economic Sciences and information technology

v. **Ethics and Professionalism**

Possess a high level of integrity, ethical conduct and professional competence including proficiency in standards and codes of practice.

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

[11] The Quality Assurance Agency for Higher Education. 2015. *Subject Benchmark Statement: Engineering*. UK, QAA.

vi. **Professional Responsibility**

Be conscious of the impacts of engineering decisions on economic, environmental, health and safety, business and the social and cultural aspects of society.

vii. **Teamwork, Leadership and Entrepreneurship**

The engineering graduate should

a) Be an active team player
b) Have sound management attitudes
c) Exercise responsibility
d) Respect cultural and other diversity
e) Respect others' opinions, be courteous and exercise collective responsibility
f) Empathetic and exercise fairness and trust
g) Apply entrepreneurial skills

viii. **Engineering Competences**

Competence in conceptualisation, design, construction, manufacture, operation and maintenance of structures, processes and systems.

ix. **Life-long Learning**

Commitment to continuous improvement, curiosity and ability to be innovative, undertake inquiry and 'think outside the box'.

The above attributes are reflected in the Expected Learning Outcomes (ELOs) for the five selected engineering programmes.

3. 4 Engineering Programmes Objectives[12,13]

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.

[12] The Quality Assurance Agency for Higher Education. 2015. *Subject Benchmark Statement: Engineering*. UK, QAA.

[13] 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.

3.4.1 ACADEMIC ABILITY

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

- Knowledge, skills, know-how and understanding for developing effective ways to solve engineering problems creatively and innovatively;
- Knowledge and know-how in scientific principles, mathematics and engineering applications;
- Ability to design and implement engineering products, processes and systems applications;
- Ability to adapt and adopt emerging engineering applications / technologies; and
- Ability to undertake research and to progress to postgraduate / higher levels of studies.

3.4.2 EMPLOYABILITY

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

- Up-to-date engineering skills for the industry;
- Problem solving skills for engineering related tasks;
- Analytical skills to understand impacts of engineering on individuals, organisations and society;
- Ability to integrate theory and practice to work effectively and efficiently in organisations; and
- Knowledge, skills, know-how and understanding that enable creativity, innovativeness and entrepreneurship in the field of engineering.

3.4.3 PERSONAL DEVELOPMENT

The programme objectives under this category are to:

- Prepare learners for life-long learning and research;
- 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;
- Equip the learner with knowledge, know-how, understanding and skills to work as a team in the engineering field; and
- Enable the learner to develop skills to perform effectively in technical and non-technical environments.

3. 5 Knowledge, Skills and Attitude Expected of All Engineering Graduates

An engineering graduate, whose attributes are indicated in section 3.4 above, is expected to demonstrate knowledge, skills and attitude that include the following, on completion of an engineering programme of study:

- A knowledge of contemporary issues;
- An ability to identify, formulate, and solve engineering problems;
- An understanding of professional and ethical responsibility;
- An ability to design and conduct experiments, as well as to analyse and interpret data;
- An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;
- An ability to function on multidisciplinary teams;
- The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;
- A recognition of the need for, and an ability to engage in life-long learning;
- An ability to apply knowledge of mathematics, science, and engineering;
- An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice;
- An ability to communicate effectively; and
- Commitment to life-long learning, continuous self and professional development and / or pursue graduate study and recognise its importance.

3. 6 Generic Expected Learning Outcomes

Following the above attributes, knowledge, skills and attitude (see Sections 3.4 and 3.5) required of an engineering graduate, the Expected Learning Outcomes (ELOs) for the programmes for the five selected fields of engineering are presented in proceeding Part 4 of this document as modifications of the generic ELOS presented in Table 3.1 below. The generic ELOs were formulated on the basis of the above graduate attributes, knowledge, skills and attitude; and in Table 3.1, each ELO is linked to the nine graduate attributes (i.e. (i)-(ix)) highlighted in Section 3.4 above. It is expected at a bachelor's engineering programme will reflect balanced ELOs for knowledge, skills (cognitive, practical and interpersonal), and attitude from the 28 indicated in

Table 3.1; and not necessarily reflecting the entire 28 that serve as ELOs selection guidelines for any given bachelor's in engineering programme.

Table 3.1: Generic Expected Learning Outcomes for a Bachelor's in Engineering Programme (e*ach ELO is linked to the graduate attributes in Section 3.4)*

Knowledge	
	The graduate should be able to: 1. Demonstrate a critical understanding of principles, theories, concepts, and facts relevant to the practice of Engineering (viii) 2. Demonstrate understanding of science, mathematics and technological advancement relevant to Engineering (iv) 3. Demonstrate understanding of the impact of Engineering solutions in a global and societal context (vi) 4. Demonstrate awareness of relevant contemporary issues (vi) 5. Explain basic concepts in business, public policy, management and leadership (vi, vii)
Skills	
Cognitive skills	***The graduate should be able to:*** 6. Design a system, component or process for varied problems in Engineering to meet desired needs including economic, environmental, social, ethical, health and safety, manufacturability, and sustainability, and understand limitations of the solutions (viii) 7. Interpret data, and draw valid conclusions for Engineering related problems and sustainable infrastructure development (viii) 8. Write computer programmes relevant to Engineering (viii) 9. Evaluate designs and propose appropriate improvements (viii) 10. Demonstrate creativity and innovativeness in solving Engineering problems (iii, viii) 11. Analyse results of numerical models and appreciate their limitations (viii) 12. Manage projects, resources and time considering legal and statutory requirements, health and safety, quality, risk, reliability and sustainability (vi, vii, viii)

Practical Skills	***The graduate should be able to:*** 13. Prepare and interpret technical drawings (i, viii) 14. Prepare technical reports and deliver technical presentations (i, viii) 15. Undertake field investigations, laboratory work, and analyse data for use in planning and design (viii) 16. Undertake basic practical work, supervision and inspection of Engineering work (ii, vii, viii) 17. Use relevant computer applications in solving Engineering problems (i, iii, viii) 18. Apply relevant specifications, standards and codes of practice (i, v) 19. Prepare and use project documentation (including specifications, plans, maps and drawings) (i, ii, viii) 20. Demonstrate entrepreneurial acumen to develop and sustain an enterprise and improve livelihood (iii, vi, vii)
Interpersonal Skills	***The graduate should be able to:*** 21. Demonstrate leadership skills in the work environment (vii, viii) 22. Demonstrate ability to work and interact in multicultural, multidisciplinary and other diverse environments (ii, vii) 23. Work effectively in a team (vii)
Attitude	
	The graduate should be able to: 24. Demonstrate commitment to life-long learning, continuous self and professional development and/or pursue graduate study and recognise its importance (ix) 25. Demonstrate an inquisitive mind, eager for new knowledge and understanding (iii, ix) 26. Empathise with stakeholders (iv, vi) 27. Uphold high moral standards in relation to professional conduct and apply appropriate ethical principles in practices (v) 28. Show self-awareness and ability to adapt to new situations (iii, ix)

3. 7 Translating Generic ELOs into the Basic and Other Phases of the Bachelor's in Engineering Programmes

The above ELOs need to be translated into an engineering programme. In this document, programmes in engineering fields are defined at bachelor's level. A programme is 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 types i.e. *core*, *supportive* and *elective*.

- *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 learner.
- *Supportive courses* are those that back up the core courses. Without these courses it will be difficult to understand the core courses; an example is "mathematics" and "Computer Fundamentals and ICT." These courses are compulsory for all learners.
- *Elective courses* are those that can be taken by a learner to deepen or broaden their 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 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).

There should be ensurance, during programme curriculum design, for sufficient coverage of requisite, pre-requisites and co-requisite courses.

A Bachelor programme in a specified field of engineering can be divided into two phases, i.e. *basic phase* and *specialisation phase*.

- The *basic phase* is common for all the specific engineering field programme's learners, and consists of core and supportive courses.
- The *specialisation phase* allows learners to choose applicable specialisations in line with their interests in the engineering field of study.

There are courses common to programmes in different fields of engineering; these are undertaken during the early stage of study which is referred to herein as the *shared phase*. Courses undertaken during the shared phase consists of core and supportive courses undertaken in the initial and advanced stages of the programmes, and are incorporated in the basic phase of the programme of a specific field of study.

These benchmarks are only concerned with the shared phase and basic phase that are undertaken by all learners irrespective of any areas of specialisation that may be undertaken within the different fields of study.

The benchmarks development process, that involved analysis of regional and international practices, established minimum / key courses to be covered in each of the selected fields' programmes. For the shared phase, the table below translates some of the ELOs in the above Section 3.6 of this Part 3 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 as indicated in the following Table 3.2. For each of the specific engineering fields, translation of learning outcomes into the basic and any specialisation phases of the programmes are indicated in requisite sections of Part 4 of this document.

It should be noted that the reference to courses hereunder and elsewhere in this document, does in some cases refer to subject areas for coverage. One or more subject areas may be reflected in one or more courses / modules / units as per the specific engineering field programme curriculum development in any HEI's undertakings.

Table 3.2: Minimum Courses / Subject Areas for the Shared Phase of a Bachelor's in Engineering Programme

Core	Supportive	Elective
Basic Engineering • Engineering Drawing • Introduction to Engineering Field • Strength of Materials • Engineering Mechanics **Engineering Fundamentals** • (courses / subject areas specific to an engineering field e.g. civil, mechanical, electrical, electronics and telecommunication or agricultural engineering) **Engineering Analysis, Design and Manufacturing** • Computer Aided Engineering Analysis and Design *(including CAD Tools)* • Design Project **Experiential Learning** • Workshop Practice • Industrial Training • Problem Based Learning (PBL) Project **Engineering Research** • Research Methodology • Research Project **Environmental Management and Sustainability**	**Basic Sciences** • Physics for Engineers • Chemistry for Engineers **Mathematics for Engineers** • Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Laplace Transforms, Fourier series, Numerical Methods, Vector Analysis)* **Programming** • Programming for Engineers*(including clanguages)* • Computer Fundamentals and ICT **Probability and Statistics** • Probability and Statistics for Engineers **Writing and Communication** • Technical Writing for Engineers	• (these are meant to deepen or broaden a learner's knowledge in a specialisation of a particular programme for a field of engineering)

Core	Supportive	Elective
• Environmental Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)* **Engineering Management and Economics** • Engineering Management *(including project management)* • Engineering Economics • Entrepreneurship *(including marketing)* **Law and Professional Practice** • Law, Ethics, Integrity and Professional Practice	• Communication Skills for Engineers **Basic Social Sciences and Humanities** • Development Studies • Sociology *(and Gender)* • Basic Economics	

3. 8 Generic ELOs and the Alignment Matrix for Shared Phase of Bachelor's in Engineering Programme

To check if the planned courses adequately cover the ELOs, it is important to develop an alignment matrix that forms part of the basic curriculum of any specific field's engineering programme. For each of the courses, specific ELOs have to be formulated and there has to be checking of how the course contributes to the programme's ELOs. The alignment of generic ELOs and courses within the shared phase of the bachelor's in engineering programme is reflected in the alignment matrices for specific field engineering programmes in Part 4 of this document.

3. 9 Experiential Learning and Project Work

Experiential learning enables learning through experience, and is more specifically referred to as "learning through reflection on doing." Hands-on learning is a form of experiential learning but does not necessarily involve learners reflecting on their outcome(s).

3.9.1 WORKSHOP PRACTICE

Workshop Practice is recommended to be conducted at the end of 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 can be arranged at the HEI and / or organised with industry. Workshop practice exposes students in the first year of study to the working environment. Students adventure into designing and making basic products, practicing with materials in a workshop setup while observing health, safety and environmental concerns. Students are exposed to different materials commonly used in the various fields of engineering. Students should ideally have at least ten weeks during the recess term or semester of their first year.

3.9.2 LABORATORY AND FIELD PRACTICE

For the learners to adequate understand the engineering field of study, programme designs should ensure sufficient learner centred exposure to field and laboratory based practical work, to enhance the learner's thought independence, creativity, innovation, team working, analysis and associated technical presentation and communication skills. Field and laboratory practice should ideally be a component of all applicable practical courses, either directly incorporated in each course or as separate units that bring together multiple courses, and must form part of the learner's assessment through reports, presentations and / or otherwise.

3.9.3 INDUSTRY AND COMMUNITY VISITS

For the learners to adequate 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, team working, technical presentation and communication skills as well as relating their learning to real life applications and challenges.

3.9.4 INDUSTRY TRAINING

The industrial training is an integral part of a Bachelor's degree course in any engineering field. It offers the learner an opportunity to relate knowledge gained at the university with real life applications in the industry. As such, an engineering programme should allow for adequate time for industrial attachment. In this way, the learner can enhance their skills, knowledge, work abilities and attitude towards their area of specialisation. Practical training forms a foundation towards producing a competent professional engineer.

The Industrial training may be conveniently scheduled before or after a teaching semester in order not to disrupt the normal teaching; however, multiple phases of industry attachment may be also be undertaken during the formal study period (in place of single block industry attachment periods or otherwise). Where formal study is supplemented by phases of industry attachment, programme durations should be sufficient to ensure full coverage of the academic requirements.

In scheduled industrial placements, learners are attached to private firms, government institutions / agencies, corporations, industrial / commercial organisations so that they can relate what they have learnt at the institutions of higher learning with actual work situations; for reasonable periods (about 10 weeks). Students should be jointly supervised by staff in the industry together with HEI staff. Students will keep a log of their activities and write reports documenting the experience they acquired and should form part of their assessment.

3.9.5 PROBLEM BASED LEARNING (BPL) PROJECT

This approach of Problem Based Learning (PBL) is used in order for the HEI to engage with community and industry to contribute to solving some of the challenges faced, and at the same time enable students learn from the engagements.

Students should be required to address real problems and learn in the process of finding suitable practicable solutions. The main supervisors should be HEI staff who will work closely with industry partners. 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. There will be identification of solutions which can be scaled up for the benefit of the wider society.

3.9.6 DESIGN PROJECT

A design 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. In many programmes, this is designed as a capstone which brings to the fore the climax of the knowledge, skills and attitudes the learners will have learnt in readiness for the job market. The design project can be for individual learners or teams. For team projects, all learners should demonstrate their contribution to avoid free riders and that is taken into account in the assessment. Assessment takes into account the ability to address the problems, social issues, economic considerations and innovativeness.

3.9.7 RESEARCH PROJECT

The objective of the research project work is to give the learner an opportunity to apply the subject matter learnt to practical problem solving under supervision of HEI academic staff. The project work should be compulsory and should be graded. The project can be done at industry or at the university. Inter-disciplinary projects (involving several fields of engineering and / or other fields) and teamwork are encouraged. Learners should identify a researchable problem, collect data and propose solutions to the community / industry using knowledge and skills acquired. At the end of the programme, the learner should be required to submit a final project report, make an oral presentation and demonstrate a working prototype wherever applicable. To be able to undertake a research project, learners should have studied research methodology, and probability and statistics.

3. 10 Teaching, Learning and Assessment[14,15]

In the design of programmes, approaches of teaching, learning and assessment should be so formulated to ensure alignment of learning activities and assessment tasks with the programmes' learning outcomes.

Teaching, learning and assessment approaches should provide opportunities for the attainment of the learning outcomes, show the attainment of learning outcomes, and recognise diverse learner backgrounds and abilities accounting for special needs (including autism, dyslexia, and e.t.c). 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 scholarship, policy alterations, industry best practices, business, entrepreneurship and employer requirements.

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[14] The Quality Assurance Agency for Higher Education. 2015. *Subject Benchmark Statement: Engineering*. UK, QAA.

[15] 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.

The design of programmes should be informed by relevant current developments, appropriate research and scholarship, and industry best practices and knowledge of the graduate engagements as a form of establishing learning achieved after graduation.

For the learners to adequate understand the engineering field of study, programme designs should ensure sufficient learner centred exposure to field and laboratory based practical work, significant individual and group activities including research centred / informed project works, case studies, industrial and community visits, and design projects to enhance the learners' thought independence, creativity, innovation and team working.

Relevant sustainability, environmental, social, economic, legal, ethical, gender and cultural considerations should inform teaching and learning methods in the design of programmes.

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 HEIs to exposure 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 limited to manufacturers, private business service engineers, public service engineers and managers. The programme designs should be so undertaken to cater for such industry participation in programme delivery.

Programmes shall be comprised of courses assessed through coursework (especially for formative assessment) and examinations (especially for summative assessment) except for audited courses; in proportions of utmost 40% and 60%, respectively.

Coursework for examinable courses shall consist of practical work (laboratory work, workshop practice and / or fieldwork) through reports, presentations, e.t.c, and continuous assessment (assignments (through reports and / or presentations) and tests).

3.10.1 ASSESSMENT OF FIELD AND WORKSHOP PRACTICE

This should be based on Assessment 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 the larger proportion to the grading as compared to the technical report.

3.10.2 ASSESSMENT OF 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.

3.10.3 ASSESSMENT OF LABORATORIES, DESIGN PROJECTS, PBL PROJECTS 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.

PART 4: BENCHMARKS FOR SELECTED ENGINEERING PROGRAMMES

In this document, benchmarks are presented for five of the eight identified engineering fields (i.e. civil, mechanical, electrical, electronics and telecommunication, and agricultural engineering; see sub-section 1.2.3).

4.1 Benchmarks for a Bachelor's in Civil Engineering Programme

4.1.1 DESCRIPTION OF CIVIL ENGINEERING

Civil engineering is a discipline that deals 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. It is traditionally broken into sub disciplines for example geotechnical, coastal, construction, earthquake, structural, environmental, transportation, municipal and water resources engineering.

4.1.2 CIVIL ENGINEERING PROGRAMME GOAL

The goal of a bachelor's in civil engineering programme is to afford a learner knowledge, skills and competence in civil engineering.

4.1.3 PROGRAMME OBJECTIVES

The objectives of a bachelor's in civil engineering programme may be grouped into three categories, namely; academic ability, employability and personal development, as elaborated in the following sub-sections.

4.1.3.1 Academic Ability

The programme objectives under this category are to:

- Equip learners with knowledge and skills for solving civil engineering problems;
- Prepare learners to engage in professional practice in industry, government and academia;
- Equip learners with the ability to undertake research and to progress to higher levels of studies in civil engineering; and
- Engage in life-long learning in the field of Civil Engineering.

4.1.3.2 Employability

The programme objectives under this category are to:

- Equip learners with knowledge and skills that enable creativity, innovativeness, management and entrepreneurship in the field of civil engineering;
- Equip learners with up-to-date civil engineering skills for the industry;
- Equip learners with analytical skills to understand the impacts of civil engineering on individuals, organisations and society; and
- Equip learners with the ability to integrate theory and practice to work effectively and efficiently in organisations.

4.1.3.3 Personal Development

The programme objectives under this category are to:

- Impart professional ethics to learners;
- Prepare learners for life-long learning and research;
- Empower learners to progress in their professional career;
- Equip the learner with competence, skills and attitude to work in multicultural and global environments;
- Prepare the learner to work as part of a team in the civil engineering field; and
- Enable the learner to develop skills for solving challenges in society, and perform effectively in technical and non-technical environments.

4.1.4 EXPECTED LEARNING OUTCOMES

A learner completing a bachelor's in civil engineering programme should be able to demonstrate the attributes, knowledge, skills and attitude highlighted in Sections 3.4 and 3.5. A tabulation of Expected Learning Outcomes (ELOs) is provided in Table 4.1 below. The ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and attitude; and linked to the graduate attributes, following modification of the generic ELOs in Table 3.1.

Table 4.1: ELOs for a Bachelor's in Civil Engineering Programme (*Each ELO is linked to the graduate attributes in Section 3.4)*

Knowledge	
	The graduate should be able to: 1. Demonstrate a critical understanding of principles, theories, concepts, and facts relevant to the practice of Civil Engineering (viii) 2. Demonstrate understanding of science, mathematics and technological advancement relevant to Civil Engineering (iv) 3. Demonstrate understanding of the impact of Civil Engineering solutions in a global and societal context (vi) 4. Demonstrate awareness of relevant contemporary issues (vi) 5. Explain basic concepts in business, public policy, management and leadership (vi, vii)
Skills	
Cognitive skills	***The graduate should be able to:*** 6. Design a system, component or process for varied problems in Civil Engineering to meet desired needs including economic, environmental, social, ethical, health and safety, manufacturability, and sustainability, and understand limitations of the solutions (viii) 7. Interpret data, and draw valid conclusions for Civil Engineering related problems and sustainable infrastructure development (viii) 8. Write computer programmes relevant to Civil Engineering (viii) 9. Evaluate designs and propose appropriate improvements (viii) 10. Demonstrate creativity and innovativeness in solving Civil Engineering problems (iii, viii) 11. Analyse results of numerical models and appreciate their limitations (viii) 12. Manage projects, resources and time considering legal and statutory requirements, health and safety, quality, risk, reliability and sustainability (vi, vii, viii)

Practical Skills	***The graduate should be able to:*** 13. Prepare and interpret technical drawings (i, viii) 14. Prepare technical reports and deliver technical presentations (i, viii) 15. Undertake field investigations, laboratory work, and analyse data for use in planning and design (viii) 16. Undertake basic practical work, supervision and inspection of Civil Engineering work (ii, vii, viii) 17. Use relevant computer applications in solving Civil Engineering problems (i, iii, viii) 18. Apply relevant specifications, standards and Codes of Practice (i, v) 19. Prepare and use project documentation (including specifications, plans, maps and drawings) (i, ii, viii) 20. Demonstrate entrepreneurial acumen to develop and sustain an enterprise and improve livelihood (iii, vi, vii)
Interpersonal Skills	***The graduate should be able to:*** 21. Demonstrate leadership skills in the work environment (vii, viii) 22. Demonstrate ability to work and interact in multicultural, multidisciplinary and other diverse environments (ii, vii) 23. Work effectively in a team (vii)
Attitude	
	The graduate should be able to: 24. Demonstrate commitment to life-long learning, continuous self and professional development and/or pursue graduate study and recognise its importance (ix) 25. Demonstrate an inquisitive mind, eager for new knowledge and understanding (iii, ix) 26. Empathise with stakeholders (iv, vi) 27. Uphold high moral standards in relation to professional conduct and apply appropriate ethical principles in practices (v) 28. Show self-awareness and ability to adapt to new situations (iii, ix)

4.1.5 TRANSLATING THE ELOS INTO THE PROGRAMME

Civil engineering has multiple key areas of specialisation; including geotechnical engineering, transportation engineering, civil engineering management, structural engineering, water resources engineering and environmental engineering. Table 4.2 below indicates the minimum courses / subject areas for a bachelor's in civil engineering programme; categorised into core, supportive and elective courses under the clusters pre-defined in Table 3.2.

Table 4.2: Minimum Courses / Subject Areas for a Bachelor's in Civil Engineering Programme

Core	Supportive	Elective
Basic Engineering • Engineering Drawing • Introduction to Civil Engineering • Fundamentals of Electrical and Mechanical Engineering • Fluid Mechanics • Engineering Hydraulics • Strength of Materials • Engineering Mechanics • Thermodynamics for Engineers **Engineering Fundamentals** • Foundation Engineering • Theory of Structures • Structural Analysis • Engineering Geology • Soil Mechanics • Engineering Hydrology • Construction Technology • Civil Engineering Materials • Engineering Surveying • Geomatics for Civil Engineering • Design of Structures *(including*	**Basic Sciences** • Physics for Engineers • Chemistry for Engineers **Mathematics for Engineers** • Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Laplace Transforms, Fourier series, Numerical Methods, Vector Analysis)* **Programming** • Programming for Engineers *(including languages)* • Computer Fundamentals and ICT **Probability and Statistics** • Probability and Statistics for Engineers **Writing and Communication**	• Earthquake Engineering • Railway Engineering • Ports and Harbours Engineering • Airport Engineering • Marine Engineering • Construction Equipment Management • Solid Waste Management • Urban Drainage and Flood Protection • Modelling and Simulation in Water Resources

Core	Supportive	Elective
Concrete, Steel, Masonry, Timber, Prestressed Concrete, Composites) • Highway Engineering • Water Resources Engineering • Public Health Engineering • Transportation and Traffic Engineering • Geotechnical Engineering • Infrastructure Maintenance and Management **Engineering Analysis, Design and Manufacturing** • Computer Aided Engineering Analysis and Design *(including CAD Tools)* • Design Project **Experiential Learning** • Workshop Practice • Industrial Training • Problem Based Learning (PBL) Project **Engineering Management and Economics** • Civil Engineering Management *(including project management)* • Construction Economics • Entrepreneurship *(including marketing)* • Elements of Quantity Surveying **Engineering Research**	• Technical Writing for Engineers • Communication Skills for Engineers **Basic Social Sciences and Humanities** • Development Studies • Sociology *(and Gender)* • Basic Economics **Law and Professional Practice** • Law, Ethics, Integrity and Professional Practice	

Core	Supportive	Elective
• Research Methodology • Research Project **Environmental Management and Sustainability** Environmental Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)*		

4.1.6 ELOS AND THE ALIGNMENT MATRIX

The learner is expected to demonstrate clearly the knowledge they have acquired after going through the full civil engineering training programme. It is expected that a learner will be able to exhibit sound grasp of science, mathematics and other related subjects, and the learner should have an understanding of the profession and its ethical responsibilities. The proceeding Table 4.3 presents an alignment of the ELOs (see Table 4.1) and the minimum courses / subject areas (see Table 4.2) for a bachelor's in civil engineering programme.

4.1.7 EXPERIENTIAL LEARNING AND PROJECT WORK

For a Bachelor's in Civil Engineering programme, the experiential learning and project work benchmarking are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

4.1.8 TEACHING, LEARNING AND ASSESSMENT

For a Bachelor's in Civil Engineering programme, the teaching, learning and assessment are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

Table 4.3: Alignment Matrix for a Bachelor's in Civil Engineering Programme's ELOs and Minimum Courses / Subject Areas

S/No.	Course / Subject Area	Expected Learning Outcomes																											
		Knowledge					Skills																	Attitude					
							Cognitive							Practical								Interpersonal							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
CORE COURSES / SUBJECT AREAS																													
	Basic Engineering																												
1	Introduction to Civil Engineering	√	√	√		√		√		√					√						√		√	√	√	√		√	√
2	Fundamentals of Electrical and Mechanical Engineering	√	√	√	√			√		√		√		√			√			√			√	√	√	√			√
3	Fluids Mechanics	√	√	√			√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
4	Engineering Hydraulics	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
5	Strength of Materials	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
6	Engineering Mechanics	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
7	Engineering Drawing	√	√	√	√		√	√		√	√			√	√		√	√	√	√		√	√	√	√	√			√
8	Thermodynamics for Engineers	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
	Engineering Fundamentals																												
9	Foundation Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
10	Theory of Structures	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
11	Structural Analysis	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
12	Construction Technology	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
12	Soil Mechanics	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√	√		√
13	Engineering Hydrology	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
14	Civil Engineering Materials	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
15	Engineering Surveying	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
16	Geomatics for Civil Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
17	Design of Structures *(including Concrete, Steel, Masonry, Timber, Prestressed Concrete, Composites)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
18	Highway Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
19	Water Resources Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
20	Public Health Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
21	Transportation and Traffic Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
22	Geotechnical Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
23	Engineering Geology	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√	√		√
24	Infrastructure Maintenance and Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Analysis, Design and Manufacturing																												
25	Computer Aided Engineering Analysis and Design *(including CAD tools)*	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
26	Design Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Experiential Learning																												
27	Workshop Practice	√	√	√	√	√					√		√	√	√		√		√	√	√	√	√	√	√	√	√	√	√

28	Industrial Training	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
29	Problem Based Learning (PBL) Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Research																												
30	Research Methodology	√	√	√	√			√				√			√	√		√				√	√	√	√	√	√	√	√
31	Research Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Environmental Management and Sustainability																												
32	Environmental Quality Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)*	√	√	√	√	√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Management and Economics																												
33	Civil Engineering Management *(including project planning and management)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
34	Construction Economics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
35	Elements of Quantity Surveying	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
36	Entrepreneurship *(including marketing)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
SUPPORTIVE COURSES / SUBJECT AREAS																													
	Basic Sciences																												
37	Physics for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
38	Chemistry for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
	Mathematics for Engineers																												
39	Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Numerical Methods and Vector Analysis)*	√	√	√	√							√										√	√	√	√	√			√
	Programming																												
40	Computer Fundamentals and ICT	√	√	√	√	√		√	√	√	√				√		√	√			√	√	√	√	√	√	√	√	√
41	Programming for Engineers *(including languages)*	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
	Probability and Statistics																												
42	Probability and Statistics for Engineers	√	√	√	√	√		√				√						√				√		√	√	√	√	√	√
	Writing and Communication																												
43	Communication Skills for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
44	Technical Writing for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
	Basic Social Sciences and Humanities																												
45	Development Studies	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
46	Sociology *(including gender)*	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
47	Basic Economics	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
	Law and Professional Practice																												
48	Law, Ethics, Integrity and Professional Practice	√	√	√	√	√	√	√					√						√	√	√	√	√	√	√	√	√	√	√
ELECTIVES COURSES / SUBJECT AREAS																													

1	Earthquake Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2	Railway Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3	Ports and Harbours Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4	Airport Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
5	Marine Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
6	Construction Equipment Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
7	Solid Waste Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
8	Urban Drainage and Flood Protection	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
9	Modelling and Simulation in Water Resources	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

4.2 Benchmarks for a Bachelor's in Mechanical Engineering Programme

4.2.1 DESCRIPTION OF MECHANICAL ENGINEERING

Mechanical engineering is the discipline that applies engineering mathematics, physics, and materials science principles to design, analyse, manufacture, and maintain mechanical systems. The mechanical engineering field requires an understanding of core subject areas especially; mechanics, dynamics, thermodynamics, materials science, structural analysis, and statics. In addition to these core areas of study, mechanical engineers use tools such as Computer-Aided Design (CAD), and product life cycle management to design and analyse manufacturing plants, industrial equipment and machinery, heating and cooling systems, transport systems, aircraft, watercraft, robotics, medical devices, weapons, and others. Technically, it is the branch of engineering that involves the design, production, and operation of machinery.

4.2.2 MECHANICAL ENGINEERING PROGRAMME GOAL

A bachelor's in mechanical engineering programme prepares its learners to become experts in industry, government, and academia in matters relating to Mechanical Engineering. Mechanical engineering graduates should have the ability to analyse, design, synthesize, and maintain engineering systems and machinery.

A bachelor's in mechanical engineering programme includes creative design, manufacturing, testing, evaluation and distribution of such devices as automobiles, home appliances, spacecraft, all types of engines, air conditioning equipment, artificial organs, nuclear and fossil fuel power plants, controls, robotics with vision systems, prosthetic limbs, and many other types of instruments.

4.2.3 PROGRAMME OBJECTIVES

The objectives of a bachelor's in mechanical engineering programme may be grouped into three categories, namely; academic ability, employability and personal development, as elaborated in the following sub-sections.

4.2.3.1 Academic Ability

The programme objectives under this category are to:

- Equip learners with mechanical engineering knowledge, skills and competences;

- Engage in professional practice in academia, industry, or government;
- Promote innovation in the design, research and implementation of products and services in the field of Mechanical Engineering through strong communication, leadership and entrepreneurial skills;
- Promote usage of energy and natural resources in a sustainable manner;
- Engage in life-long learning in the field of mechanical engineering; and
- Have ability to recognise ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

4.2.3.2 Employability

The programme objectives under this category are to:

- Equip learners with mechanical engineering technical skills, entrepreneurial and managerial skills;
- Prepare learners to have right attitude to work, team work and ability to communicate effectively;
- Have ability to apply both analysis and synthesis in the engineering design process, resulting in designs that meet desired needs of the customers / users; and
- Have ability to develop and conduct appropriate experiments, analyse and interpret data, and use engineering judgment to draw conclusions.

4.2.3.3 Personal Development

The programme objectives under this category are to:

- Impart professional ethics to learners;
- Prepare learners for life-long learning and research;
- Empower learners to progress in their professional career;
- Equip the learners with skills and attitude to work in multicultural and global environments;
- Equip the learners with knowledge and skills to be able to work independently and as a member of team; and
- Make the learner to develop skills to perform effectively in technical and non-technical settings.

4.2.4 EXPECTED LEARNING OUTCOMES

A learner completing a bachelor's in mechanical engineering programme should be able to demonstrate the attributes, knowledge, skills and attitude highlighted in Sections 3.4 and 3.5. A tabulation of Expected Learning Outcomes (ELOs) is provided in Table 4.4 below. The ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and attitude; and linked to the graduate attributes, following modification of the generic ELOs in Table 3.1.

Table 4.4: ELOs for a Bachelor's in Mechanical Engineering Programme (*Each ELO is linked to the graduate attributes in Section 3.4)*

Knowledge	
	The graduate should be able to: 1. Demonstrate a critical understanding of principles, theories, concepts, and facts relevant to the practice of Mechanical Engineering (viii) 2. Demonstrate understanding of science, mathematics and technological advancement relevant to Mechanical Engineering (iv) 3. Demonstrate understanding of the impact of Mechanical Engineering solutions in a global and societal context (vi) 4. Demonstrate awareness of relevant contemporary issues (vi) 5. Explain basic concepts in business, public policy, management and leadership (vi, vii)
Skills	
Cognitive skills	***The graduate should be able to:*** 6. Design a system, component or process for varied problems in Mechanical Engineering to meet desired needs including economic, environmental, social, ethical, health and safety, manufacturability, and sustainability, and understand limitations of the solutions (viii) 7. Interpret data, and draw valid conclusions for Mechanical Engineering related problems and sustainable infrastructure development (viii) 8. Write computer programmes relevant to Mechanical Engineering (viii) 9. Evaluate designs and propose appropriate improvements (viii) 10. Demonstrate creativity and innovativeness in solving Mechanical Engineering problems (iii, viii)

	11. Analyse results of numerical models and appreciate their limitations (viii) 12. Manage projects, resources and time considering legal and statutory requirements, health and safety, quality, risk, reliability and sustainability (vi, vii, viii)
Practical Skills	***The graduate should be able to:*** 13. Prepare and interpret technical drawings (i, viii) 14. Prepare technical reports and deliver technical presentations (i, viii) 15. Undertake field investigations, laboratory work, and analyse data for use in planning and design (viii) 16. Undertake basic practical work, supervision and inspection of Mechanical Engineering work (ii, vii, viii) 17. Use relevant computer applications in solving Mechanical Engineering problems (i, iii, viii) 18. Apply relevant specifications, standards and codes of practice (i, v) 19. Prepare and use project documentation (including specifications, plans, maps and drawings) (i, ii, viii) 20. Demonstrate entrepreneurial acumen to develop and sustain an enterprise and improve livelihood (iii, vi, vii)
Interpersonal Skills	***The graduate should be able to:*** 21. Demonstrate leadership skills in the work environment (vii, viii) 22. Demonstrate ability to work and interact in multicultural, multidisciplinary and other diverse environments (ii, vii) 23. Work effectively in a team (vii)
Attitude	
	The graduate should be able to: 24. Demonstrate commitment to life-long learning, continuous self and professional development and/or pursue graduate study and recognise its importance (ix) 25. Demonstrate an inquisitive mind, eager for new knowledge and understanding (iii, ix) 26. Empathise with stakeholders (iv, vi) 27. Uphold high moral standards in relation to professional conduct and apply

	appropriate ethical principles in practices (v) 28. Show self-awareness and ability to adapt to new situations (iii, ix)

4.2.5 TRANSLATING THE ELOS INTO THE PROGRAMME

Mechanical engineering is a wide discipline with major sub-themes comprising core courses including Principles of Engineering, Control, Design, Dynamics, Fluid mechanics, Manufacturing, Materials, Statics and Solid Mechanics. These courses have learning outcomes that contribute to the development of a mechanical engineer. Table 4.5 below indicates the minimum courses / subject areas for a bachelor's in mechanical engineering programme; categorised into core, supportive and elective courses under the clusters pre-defined in Table 3.2.

Table 4.5: Minimum Courses / Subject Areas for a Bachelor's in Mechanical Engineering Programme

Core	Supportive	Elective
Basic Engineering • Engineering Drawing • Fundamentals of Electrical and Mechanical Engineering • Production Management and Simulation • Engineering Metrology and Instrumentation **Engineering Fundamentals** • Thermo-Fluids • Principles of Thermodynamics • Applied Thermodynamics • Applied Engineering • Heat Transfer • Statics and Dynamics • Fluid Mechanics • Mechanics of Machines	**Basic Sciences** • Physics for Engineers • Chemistry for Engineers **Mathematics for Engineers** • Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Laplace Transforms, Fourier series, Numerical Methods, Vector Analysis)* **Programming** • Programming for Engineers *(including languages)* • Computer Fundamentals and	• Railway Engineering • Refrigeration and Air Conditioning • Energy Production • Industrial Robotics and Automation • Reliability Maintenance Engineering • Energy Utilisation and Management • Automotive Engine Technology • Automotive Technology • Introduction to Aeronautical Engineering

Core	Supportive	Elective
• Sheet Metal Forming Processes <u>Electrical Technology</u> • Fundamentals of Electrical Technology • Introduction to Electronics Engineering • Electrical Devices and Machines • Control and Instrumentation <u>Materials</u> • Materials Science • Materials Technology • Mechanics of Materials • Strength of Materials <u>Production Engineering</u> • Production Technology • Welding and Fabrication • Foundry Technology • Plastics Processing Technology • Ceramics Technology • Manufacturing Engineering Technology • Machine tool Technology • Mechanical Power Transmission **Engineering Analysis, Design and Manufacturing** • Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) • Computer Integrated Manufacturing (CIM)	ICT **Probability and Statistics** • Probability and Statistics for Engineers **Writing and Communication** • Technical Writing for Engineers • Communication Skills for Engineers **Basic Social Sciences and Humanities** • Development Studies • Sociology *(and Gender)* • Basic Economics **Law and Professional Practice** • Law, Ethics, Integrity and Professional Practice	• Procurement and Logistics Management • Introduction to Petroleum Engineering • Mechanical Building Services • Artificial Intelligence • Powder metallurgy • Welding metallurgy • Mechanical Vibrations • Tribology • Fracture of Materials • Human Factor Ergonomics • Composite Materials • Introduction to Bio-medical Engineering • Corrosion

Core	Supportive	Elective
• Mechanical Engineering Design • Design Project **Experiential Learning** • Workshop Practice • Industrial Training • Problem Based Learning (PBL) Project **Engineering Management and Economics** • Mechanical Engineering Management *(including project management)* • Entrepreneurship *(including marketing)* • Manufacturing Strategy • Production Operations and Management • Engineering Economics **Engineering Research** • Research Methodology • Research Project **Environmental Management and Sustainability** Environmental Management and Sustainability *(including ESIA, EA, and Health and Safety Practice)*		

4.2.6 ELOS AND THE ALIGNMENT MATRIX

The learner is expected to demonstrate clearly the knowledge they have acquired after going through the full mechanical engineering training programme. It is expected that a learner will be able to exhibit sound grasp of science, mathematics and other related subjects, and the learner should have an understanding of the profession and its ethical responsibilities. The proceeding Table 4.6 presents an alignment of the ELOs (see Table 4.1) and the minimum courses / subject areas (see Table 4.2) for a bachelor's in mechanical engineering programme.

4.2.7 EXPERIENTIAL LEARNING AND PROJECT WORK

For a Bachelor's in Mechanical Engineering programme, the experiential learning and project work benchmarking are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

4.2.8 TEACHING, LEARNING AND ASSESSMENT

For a Bachelor's in Mechanical Engineering programme, the teaching, learning and assessment are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

Table 4.6: Alignment Matrix for a Bachelor's in Mechanical Engineering Programme's ELOs and Minimum Courses / Subject Areas

S/No.	Course / Subject Area	Expected Learning Outcomes																											
		Knowledge					Skills																		Attitude				
							Cognitive							Practical								Interpersonal							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
CORE COURSES / SUBJECT AREAS																													
	Basic Engineering																												
1	Engineering Metrology and Instrumentation	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√		√	√					√	√	√	√	√
2	Fundamentals of Electrical and Mechanical Engineering	√	√	√	√			√		√		√		√			√			√			√	√	√	√			√
3	Production Management and Simulation	√		√	√	√	√				√		√		√			√							√	√			√
4	Engineering Drawing	√	√	√	√		√	√		√	√			√	√		√	√	√	√		√	√	√	√	√			√
	Engineering Fundamentals																												
5	Fluid Mechanics	√	√	√			√	√		√	√	√				√			√						√	√		√	√
6	Fluid Machinery	√	√	√			√	√		√	√	√				√			√						√	√			√
7	Strength of Materials	√	√	√	√		√	√		√	√	√		√	√	√	√	√	√	√					√		√		√
8	Engineering Mechanics	√	√	√	√		√	√		√	√	√		√	√	√	√	√	√	√				√	√	√	√	√	√
9	Production Technology	√		√	√		√			√	√			√	√	√			√	√	√				√	√	√	√	√
10	Welding and Fabrication	√		√			√			√	√			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
11	Foundry Technology	√		√			√			√	√			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
12	Plastics Processing Technology	√	√		√		√	√	√	√	√	√		√	√	√	√		√	√	√				√	√			√
13	Ceramics Technology	√	√	√	√		√	√		√	√	√			√	√	√	√	√	√	√			√	√	√	√	√	√
14	Machine Tool Technology	√	√	√	√		√	√		√	√			√	√	√	√			√	√			√	√	√			√
15	Materials Science	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√				√		√		√
16	Materials Technology	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√				√		√	√	√
17	Mechanics of Materials	√	√	√	√		√	√		√	√	√		√	√	√	√		√	√	√				√			√	√
18	Mechanics of Machines	√	√	√	√		√	√		√	√	√		√	√	√	√		√	√				√	√	√			√
19	Mechanical Power Transmission	√	√	√			√	√			√	√		√	√			√	√	√					√	√	√	√	√
20	Statics and Dynamics	√		√	√			√	√	√	√	√	√	√	√	√			√	√						√	√	√	√
21	Principles of Thermodynamics	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
22	Applied Thermodynamics	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
23	Fundamentals of Electrical Technology	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

24	Analogue & Digital Electronics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
25	Electrical Devices and Machines	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
26	Control and Instrumentation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
27	Manufacturing Engineering Technology	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Analysis, Design and Manufacturing																												
28	CAD/CAM Engineering	√	√		√		√	√	√	√	√	√	√	√	√	√		√	√	√	√				√	√			√
29	Computer Integrated Manufacturing (CIM)	√	√		√		√	√	√	√	√	√	√	√	√	√		√	√	√	√				√	√			√
30	Mechanical Engineering Design	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
31	Design Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Experiential Learning																												
32	Workshop Practice	√	√	√	√	√					√		√	√	√		√		√	√	√	√	√	√	√	√	√	√	√
33	Industrial Training	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
34	Problem Based Learning (PBL) Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Research																												
35	Research Methodology	√	√	√	√			√				√			√	√		√				√	√	√	√	√	√	√	√
36	Research Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Environmental Management and Sustainability																												
37	Environmental Quality Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)*	√	√	√	√	√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Management and Economics																												
38	Mechanical Engineering Management *(including project planning and management)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
39	Engineering Economics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
40	Manufacturing Strategy	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
41	Production Operations and Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
42	Entrepreneurship *(including marketing)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
SUPPORTIVE COURSES / SUBJECT AREAS																													
	Basic Sciences																												
43	Physics for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
44	Chemistry for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
	Mathematics for Engineers																												
45	Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Numerical*	√	√	√	√							√										√	√	√	√	√			√

	Methods and Vector Analysis)																												
	Programming																												
46	Computer Fundamentals and ICT	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
47	Programming for Engineers *(including languages)*	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
	Probability and Statistics																												
48	Probability and Statistics for Engineers	√	√	√	√	√		√				√						√				√		√	√	√	√	√	√
	Writing and Communication																												
49	Communication Skills for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
50	Technical Writing for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
	Basic Social Sciences and Humanities																												
51	Development Studies	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
52	Sociology *(including gender)*	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
53	Basic Economics	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
	Law and Professional Practice																												
54	Law, Ethics, Integrity and Professional Practice	√	√	√	√	√	√	√					√						√	√	√	√	√	√	√	√	√	√	√
ELECTIVES COURSES / SUBJECT AREAS																													
1	Energy Production	√	√		√	√	√	√			√	√	√		√				√						√	√	√	√	√
2	Refrigeration and Air Conditioning	√	√	√		√	√		√		√				√			√							√		√	√	√
3	Industrial Robotics and Automation	√	√	√		√	√		√		√				√			√							√		√	√	√
4	Reliability Maintenance Engineering	√	√	√	√		√	√	√	√	√		√		√		√	√							√	√	√	√	
5	Energy Utilisation	√	√		√	√	√	√			√	√	√		√				√						√	√	√	√	√
6	Automotive Engine Technology	√	√		√			√			√				√		√		√		√	√	√		√		√		√
7	Automotive Technology	√	√		√			√			√				√		√		√		√	√	√		√		√		√
8	Introduction to Aeronautical Engineering	√			√			√			√				√		√		√		√	√	√		√		√		√
9	Procurement and Logistics Management				√								√						√	√	√	√	√	√	√	√	√	√	√
10	Introduction to Petroleum Engineering	√			√			√			√				√		√		√		√	√	√		√		√		
11	Mechanical Building Services	√	√	√		√	√		√		√				√			√							√		√	√	√
12	Artificial Intelligence	√	√	√		√	√		√		√				√			√							√		√	√	√
13	Powder Metallurgy	√		√			√			√	√			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
14	Welding Metallurgy	√		√			√			√	√			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
15	Mechanical Vibrations	√	√	√		√	√		√		√				√			√							√		√	√	√

16	Tribology	√	√	√		√	√		√		√				√			√							√		√	√	√
17	Fracture of Materials	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√				√		√		√
18	Human Factor Ergonomics				√	√	√			√		√									√	√	√						√
19	Composite Materials	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√				√		√		√
20	Introduction to Bio-medical Engineering	√			√		√			√				√	√				√	√					√	√			√
21	Corrosion	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√				√		√		√

4.3 Benchmarks for a Bachelor's in Electrical Engineering Programme

4.3.1 DESCRIPTION OF ELECTRICAL ENGINEERING

Electrical engineering is a professional engineering discipline that generally deals with the study and application of electricity, electronics, and electromagnetism to electrical networks and electric power systems. It deals with the study, production, transport, distribution, electrical building installation, principles of electrical machines, working of electrical energy in different forms from different sources. Electrical engineers work in a very wide range of industries, and the skills required are likewise variable; ranging from basic circuit theory to the management skills required of a project manager.

4.3.2 ELECTRICAL ENGINEERING PROGRAMME GOAL

The goal of a bachelor's in electrical engineering programme is to equip learners with the knowledge and skills to design and interpret the electrical drawings in power generation, transport, distribution, electrical building installation and power utilisation.

4.3.3 PROGRAMME OBJECTIVES

The objectives of a bachelor's in electrical engineering programme may be grouped into three categories, namely; academic ability, employability and personal development, as elaborated in the following sub-sections.

4.3.3.1 Academic Ability

The programme objectives under this category are to:

- Equip learners with electrical engineering knowledge, skills and Competences;
- Engage in professional practice in academia, industry, or government;
- Promote innovation in the design, research and implementation of products and services in the field of electrical engineering through strong communication, leadership and entrepreneurial skills; and
- Engage in life-long learning in the field of electrical engineering.

4.3.3.2 Employability

The programme objectives under this category are to:

- Equip learners with knowledge and skills that enable creativity, innovativeness, management and entrepreneurship in the field of electrical engineering;
- Equip learners with up-to-date electrical engineering skills for the industry;
- Equip learners with analytical skills to understand the impact of electrical engineering on individuals, organisations, businesses and the environment; and
- Equip learners with the ability to integrate theory and state-of-the-art developments in the labour market to work effectively and efficiently.

4.3.3.3 Personal Development

The programme objectives under this category are to:

- Impart professional ethics to learners;
- Prepare learners for life-long learning and research;
- Empower learners to progress in their personal carrier;
- Equip the learner with skills and attitude to work in multicultural and global environments;
- Equip the learner with knowledge and skills to work as a team in the electrical engineering field; and
- Enable the learner to develop skills to perform effectively in technical and non-technical environments.

4.3.4 EXPECTED LEARNING OUTCOMES

A learner completing a bachelor's in electrical engineering programme should be able to demonstrate the attributes, knowledge, skills and attitude highlighted in Sections 3.4 and 3.5. A tabulation of Expected Learning Outcomes (ELOs) is provided in Table 4.7 below. The ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and attitude; and linked to the graduate attributes, following modification of the generic ELOs in Table 3.1.

Table 4.7: ELOs for a Bachelor's in Electrical Engineering Programme (*Each ELO is linked to the graduate attributes in Section 3.4)*

Knowledge	
	The graduate should be able to: 1. Demonstrate a critical understanding of principles, theories, concepts, and facts relevant to the practice of Electrical Engineering (viii) 2. Demonstrate understanding of science, mathematics and technological

	advancement relevant to Electrical Engineering (iv) 3. Demonstrate understanding of the impact of Electrical Engineering solutions in a global and societal context (vi) 4. Demonstrate awareness of relevant contemporary issues (vi) 5. Explain basic concepts in business, public policy, management and leadership (vi, vii)
Skills	
Cognitive skills	***The graduate should be able to:*** 6. Design a system, component or process for varied problems in Electrical Engineering to meet desired needs including economic, environmental, social, ethical, health and safety, manufacturability, and sustainability, and understand limitations of the solutions (viii) 7. Interpret data, and draw valid conclusions for Electrical Engineering related problems and sustainable infrastructure development (viii) 8. Write computer programmes relevant to Electrical Engineering (viii) 9. Evaluate designs and propose appropriate improvements (viii) 10. Demonstrate creativity and innovativeness in solving Electrical Engineering problems (iii, viii) 11. Analyse results of numerical models and appreciate their limitations (viii) 12. Manage projects, resources and time considering legal and statutory requirements, health and safety, quality, risk, reliability and sustainability (vi, vii, viii)
Practical Skills	***The graduate should be able to:*** 13. Prepare and interpret technical drawings (i, viii) 14. Prepare technical reports and deliver technical presentations (i, viii) 15. Undertake field investigations, laboratory work, and analyse data for use in planning and design (viii) 16. Undertake basic practical work, supervision and inspection of Electrical Engineering work (ii, vii, viii) 17. Use relevant computer applications in solving Electrical Engineering problems (i, iii, viii) 18. Apply relevant specifications, standards and Codes of Practice (i, v)

	19. Prepare and use project documentation (including specifications, plans, maps and drawings) (i, ii, viii) 20. Demonstrate entrepreneurial acumen to develop and sustain an enterprise and improve livelihood (iii, vi, vii)
Interpersonal Skills	***The graduate should be able to:*** 21. Demonstrate leadership skills in the work environment (vii, viii) 22. Demonstrate ability to work and interact in multicultural, multidisciplinary and other diverse environments (ii, vii) 23. Work effectively in a team (vii)
Attitude	
	The graduate should be able to: 24. Demonstrate commitment to life-long learning, continuous self and professional development and/or pursue graduate study and recognise its importance (ix) 25. Demonstrate an inquisitive mind, eager for new knowledge and understanding (iii, ix) 26. Empathise with stakeholders (iv, vi) 27. Uphold high moral standards in relation to professional conduct and apply appropriate ethical principles in practices (v) 28. Show self-awareness and ability to adapt to new situations (iii, ix)

4.3.5 TRANSLATING THE ELOS INTO THE PROGRAMME

Table 4.8 below indicates the minimum courses / subject areas for a bachelor's in electrical engineering programme; categorised into core, supportive and elective courses under the clusters pre-defined in Table 3.2.

Table 4.8: Minimum Courses / Subject Areas for a Bachelor's in Electrical Engineering Programme

<table>
<tr><th>Core</th><th>Supportive</th><th>Elective</th></tr>
<tr>
<td>Basic Engineering
• Introduction to Electrical Engineering
• Engineering Drawing
• Principles of Electrical Engineering
• Fluid Mechanics
• Strength of Materials
• Mechanics for Electrical Engineers
• Electrochemical Sources
• Electrical Drawing (including CAD)
• DC Network Theorems
• AC Fundamentals

Engineering Fundamentals
• Electrical DC Machines
• Electrical Network Analysis
• Microprocessors / Microcontrollers
• Electrical Circuit Theory (ECT)
• Electromagnetic Fields
• Electric Traction Systems
• Electric Heating
• Analogue Electronics
• Digital Electronics
• Control Engineering
• Power Electronics and Drives
• Electrical Power Systems and Power System Management
• Conventional and Non-conventional Power Generation
• Power Utilisation and Illumination</td>
<td>Basic Sciences
• Physics for Engineers
• Chemistry for Engineers

Mathematics for Engineers
• Mathematics for Engineers (including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Laplace Transforms, Fourier series, Numerical Methods, Vector Analysis)

Programming
• Programming for Engineers (including languages)
• Computer Fundamentals and ICT
• Database Systems

Probability and Statistics
• Probability and Statistics for Engineers

Writing and Communication
• Technical Writing for Engineers
• Communication Skills for Engineers

Basic Social Sciences and Humanities</td>
<td>• Design and Installation of substation Equipment
• Power Transmission and Distribution Design
• Electrical Installation Design
• Automation and Smart Grid
• Special Electrical Machines
• Motor Rewinding
• Mechatronics
• Introduction to Biomedical Engineering</td>
</tr>
</table>

Core	Supportive	Elective
• Electrical AC Machines and Transformers • Power Transmission and Distribution • Electrical Engineering Specifications, Standards and Codes of Practice • Electrical Measurement and Instrumentation • Industrial Health, Safety and Maintenance **Engineering Analysis, Design and Manufacturing** • Computer Aided Engineering Analysis and Design *(including CAD Tools)* • Design Project **Experiential Learning** • Workshop Practice *(to include electrical and mechanical workshops)* • Electrical Installation • Industrial Training • Problem Based Learning (PBL) Project **Engineering Management and Economics** • Electrical Engineering Management *(including project management)* • Engineering Economics • Entrepreneurship *(including*	• Development Studies • Sociology *(and Gender)* • Basic Economics **Law and Professional Practice** • Law, Ethics, Integrity and Professional Practice	

Core	Supportive	Elective
marketing) **Engineering Research** • Research Methodology • Research Project **Environmental Management and Sustainability** Environmental Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)*		

4.3.6 ELOS AND THE ALIGNMENT MATRIX

The learner is expected to demonstrate clearly the knowledge they have acquired after going through the full electrical engineering training programme. It is expected that a learner will be able to exhibit sound grasp of science, mathematics and other related subjects, and the learner should have an understanding of the profession and its ethical responsibilities. The proceeding Table 4.9 presents an alignment of the ELOs (see Table 4.1) and the minimum courses / subject areas (see Table 4.2) for a bachelor's in civil engineering programme.

4.3.7 EXPERIENTIAL LEARNING AND PROJECT WORK

For a Bachelor's in Electrical Engineering programme, the experiential learning and project work benchmarking are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

4.3.8 TEACHING, LEARNING AND ASSESSMENT

For a Bachelor's in Electrical Engineering programme, the teaching, learning and assessment are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

Table 4.9: Alignment Matrix for a Bachelor's in Electrical Engineering Programme's ELOs and Minimum Courses / Subject Areas

S/No.	Course / Subject Area	Expected Learning Outcomes																											
		Knowledge					Skills																	Attitude				
							Cognitive							Practical								Interpersonal							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
CORE COURSES / SUBJECT AREAS																													
	Basic Engineering																												
1	Introduction to Electrical Engineering	√	√	√		√		√		√					√						√		√	√	√	√		√	√
2	Principles of Electrical Engineering	√	√	√	√			√		√		√		√			√			√			√	√	√	√			√
3	Fluids Mechanics	√	√	√			√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
4	AC Fundamentals	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
5	Strength of Materials	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
6	Electrochemical Sources	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
7	DC Network Theorems	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
8	Mechanics for Electrical Engineers	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
9	Engineering Drawing	√	√	√	√		√	√		√	√			√	√		√	√	√	√		√	√	√	√	√			√
10	Electrical Drawing *(including CAD)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Fundamentals																												
11	Microprocessors / Microcontrollers	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
12	Electrical Network Analysis	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
13	Electrical DC Machines	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
14	Electromagnetic Fields	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
15	Electric Traction Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
16	Electric Heating	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
17	Analogue Electronics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
18	Digital Electronics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
19	Control Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
20	Power Electronics and Drives	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
21	Electrical Power Systems and Power System Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
22	Conventional and Non-conventional Power Generation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
23	Power Utilisation and Illumination	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
24	Electrical AC Machines and Transformers	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
25	Power Transmission and Distribution	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
26	Electrical Measurement and Instrumentation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
27	Electrical Circuit Theory (ECT)	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
28	Electrical Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

	Specifications, Standards and Codes of Practice																												
29	Industrial Health, Safety and Maintenance	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Analysis, Design and Manufacturing																												
30	Computer Aided Engineering Analysis and Design *(including CAD tools)*	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
31	Design Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Experiential Learning																												
32	Workshop Practice *(to include electrical and mechanical workshops)*	√	√	√	√	√					√		√	√	√		√		√	√	√	√	√	√	√	√	√	√	√
33	Electrical Installation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
34	Industrial Training	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
35	Problem Based Learning (PBL) Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Research																												
36	Research Methodology	√	√	√	√			√				√			√	√		√				√	√	√	√	√	√	√	√
37	Research Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Environmental Management and Sustainability																												
38	Environmental Quality Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)*	√	√	√	√	√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Management and Economics																												
39	Electrical Engineering Management *(including project planning and management)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
40	Engineering Economics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
41	Entrepreneurship *(including marketing)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
SUPPORTIVE COURSES / SUBJECT AREAS																													
	Basic Sciences																												
42	Physics for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
43	Chemistry for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
	Mathematics for Engineers																												
44	Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Numerical Methods and Vector Analysis)*	√	√	√	√							√										√	√	√	√	√			√
	Programming																												
45	Computer Fundamentals and ICT	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√

46	Programming for Engineers *(including languages)*	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
47	Database Systems	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
	Probability and Statistics																												
48	Probability and Statistics for Engineers	√	√	√	√	√		√				√						√				√		√	√	√	√	√	√
	Writing and Communication																												
49	Communication Skills for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
50	Technical Writing for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
	Basic Social Sciences and Humanities																												
51	Development Studies	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
52	Sociology *(including gender)*	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
53	Basic Economics	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
	Law and Professional Practice																												
54	Law, Ethics, Integrity and Professional Practice	√	√	√	√	√	√	√					√						√	√	√	√	√	√	√	√	√	√	√
ELECTIVES COURSES / SUBJECT AREAS																													
1	Design and Installation of substation Equipment	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2	Power Transmission and Distribution Design	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3	Electrical Installation Design	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4	Automation and Smart Grid	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
5	Special Electrical Machines	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
6	Motor Rewinding	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
7	Mechatronics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
8	Introduction to Biomedical Engineering	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√

4.4 Benchmarks for a Bachelor's in Electronics and Telecommunication Engineering Programme

4.4.1 DESCRIPTION OF ELECTRONICS AND TECOMMUNICATION ENGINEERING

Electronics and Telecommunication Engineering falls under the broad area of electrical engineering. Electronics and Telecommunication Engineering as a discipline consists of electronic hardware components, media, and networks used to transmit information over distances. Electronics and Telecommunication Engineering deals with the electronic devices, circuits, communication equipment, analogue and digital transmission and reception of information, antenna and wave propagation.

4.4.2 ELECTRONICS AND TECOMMUNICATION ENGINEERING PROGRAMME GOAL

A bachelor's in Electronics and Telecommunication Engineering programmes aims at deepening the knowledge and skills of the learners on the basic concepts and theories that will equip them in their professional work involving analysis, systems implementation, operation, production, and maintenance of the various applications in the field of Electronics and Telecommunication Engineering. IT should deliver an educational programme of study that prepares its graduates to become intellectual leaders in industry, government, and academia. Electronics and Telecommunication Engineers will acquire the ability to analyse and design electronic devices, circuits, communication equipment, transmission and reception of information, antenna and wave propagation, wired and wireless communication systems and networks.

4.4.3 PROGRAMME OBJECTIVES

The objectives of a bachelor's in electronics and telecommunication engineering programme may be grouped into three categories, namely; academic ability, employability and personal development, as elaborated in the following sub-sections.

4.4.3.1 Academic Ability

The programme objectives under this category are to:

- Equip learners with Electronic and Telecommunication engineering knowledge, skills and competences;

- Engage in professional practice in academia, industry, or government;
- Promote innovation in the design, research and implementation of products and services in the field of Electronic and Telecommunication engineering through strong communication, leadership and entrepreneurial skills; and
- Engage in life-long learning in the field of Electronic and Telecommunication Engineering.

4.4.3.2 Employability

The programme objectives under this category are to:

- Equip learners with knowledge and skills that enable creativity, innovativeness, management and entrepreneurship in the field of Electronics and Telecommunication Engineering;
- Equip learners with up-to-date skills for the industry in Electronics and Telecommunication Engineering;
- Equip learners with analytical skills to understand the impacts of Electronic and Telecommunication Engineering on individuals, organisations and society; and
- Equip learners with the ability to integrate theory and practice to work effectively and efficiently in organisations.

4.4.3.3 Personal Development

The programme objectives under this category are to:

- Impart professional ethics to learners;
- Prepare learners for life-long learning and research;
- Empower learners to progress in their personal carrier;
- Equip the learner with skills and attitude to work in multicultural and global environments;
- Equip the learner with knowledge and skills to work as a team in the Electronic and Telecommunication Engineering field; and
- Enable the learner to develop skills to perform effectively in technical and non-technical environments.

4.4.4 EXPECTED LEARNING OUTCOMES

A learner completing a bachelor's in electronics and telecommunication engineering programme should be able to demonstrate the attributes, knowledge, skills and attitude highlighted in Sections 3.4 and 3.5. A tabulation of Expected Learning Outcomes (ELOs) is provided in Table 4.10

below. The ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and attitude and linked to the graduate attributes, following modification of the generic ELOs in Table 3.1.

Table 4.10: ELOs for a Bachelor's in Electronics and Telecommunication Engineering Programme (*Each ELO is linked to the graduate attributes in Section 3.4)*

Knowledge	
	The graduate should be able to: 1. Demonstrate a critical understanding of principles, theories, concepts, and facts relevant to the practice of Electronic and Telecommunication Engineering (viii) 2. Demonstrate understanding of science, mathematics and technological advancement relevant to Electronic and Telecommunication Engineering (iv) 3. Demonstrate understanding of the impact of Electronic and Telecommunication Engineering solutions in a global and societal context (vi) 4. Demonstrate awareness of relevant contemporary issues (vi) 5. Explain basic concepts in business, public policy, management and leadership (vi, vii)
Skills	
Cognitive skills	***The graduate should be able to:*** 6. Design a system, component or process for varied problems in Electronic and Telecommunication Engineering to meet desired needs including economic, environmental, social, ethical, health and safety, manufacturability, and sustainability, and understand limitations of the solutions (viii) 7. Interpret data, and draw valid conclusions for Electronic and Telecommunication Engineering related problems and sustainable infrastructure development (viii) 8. Write computer programmes relevant to Electronic and Telecommunication Engineering (viii) 9. Evaluate designs and propose appropriate improvements (viii) 10. Demonstrate creativity and innovativeness in solving Electronic and Telecommunication Engineering problems (iii, viii) 11. Analyse results of numerical models and appreciate their limitations (viii) 12. Manage projects, resources and time considering legal and statutory requirements, health and safety, quality, risk, reliability and sustainability (vi, vii, viii)

Practical Skills	***The graduate should be able to:*** 13. Prepare and interpret technical drawings (i, viii) 14. Prepare technical reports and deliver technical presentations (i, viii) 15. Undertake field investigations, laboratory work, and analyse data for use in planning and design (viii) 16. Undertake basic practical work, supervision and inspection of Electronic and Telecommunication Engineering work (ii, vii, viii) 17. Use relevant computer applications in solving Electronic and Telecommunication Engineering problems (i, iii, viii) 18. Apply relevant specifications, standards and codes of practice (i, v) 19. Prepare and use project documentation (including specifications, plans, maps and drawings) (i, ii, viii) 20. Demonstrate entrepreneurial acumen to develop and sustain an enterprise and improve livelihood (iii, vi, vii)
Interpersonal Skills	***The graduate should be able to:*** 21. Demonstrate leadership skills in the work environment (vii, viii) 22. Demonstrate ability to work and interact in multicultural, multidisciplinary and other diverse environments (ii, vii) 23. Work effectively in a team (vii)
Attitude	
	The graduate should be able to: 24. Demonstrate commitment to life-long learning, continuous self and professional development and/or pursue graduate study and recognise its importance(ix) 25. Demonstrate an inquisitive mind, eager for new knowledge and understanding (iii, ix) 26. Empathise with stakeholders (iv, vi) 27. Uphold high moral standards in relation to professional conduct and apply appropriate ethical principles in practices (v) 28. Show self-awareness and ability to adapt to new situations (iii, ix)

4.4.5 TRANSLATING THE ELOS INTO THE PROGRAMME

Table 4.11 below indicates the minimum courses / subject areas for a bachelor's in electronics and telecommunication engineering programme; categorised into core, supportive and elective courses under the clusters pre-defined in Table 3.2.

Table 4.11: Minimum Courses / Subject Areas for a Bachelor's in Electronics and Telecommunication Engineering Programme

Core	Supportive	Elective
Basic Engineering • Introduction to Electronics and Telecommunication Engineering • Engineering Drawing • Fluid Mechanics • Strength of Materials • Mechanics for Electrical Engineers • Principles of Electrical Engineering • DC Network Theorems • AC Fundamentals • Electrical Drawing **Engineering Fundamentals** • Electrical Network Analysis • Electrical Circuit Theory • Electrical DC Machines • Electrical AC Machines and Transformers • Electrical Engineering Specifications, Standards and Codes of Practice • Electrical Measurement and Instrumentation • Industrial Health, Safety and Maintenance • Electromagnetic Fields • Power Electronics and Drives • Electrostatics and Electrodynamics • Signals and Systems: Control Systems	**Basic Sciences** • Physics for Engineers • Chemistry for Engineers **Mathematics for Engineers** • Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Laplace Transforms, Fourier series, Numerical Methods, Vector Analysis)* **Programming** • Programming for Engineers *(including languages)* • Computer Fundamentals and ICT • Database Systems **Probability and Statistics** • Probability and Statistics for Engineers **Writing and Communication** • Technical Writing for Engineers • Communication Skills for Engineers **Basic Social Sciences and Humanities**	• Embedded Systems • Artificial Intelligence • Machine Learning • Robotics • Wireless Sensor Networks • Internet of Things (IoT) • Nano and Micro Electronics • High-Speed Transmissions and Applications • Mobile Application Development • PowerLine Communication (PLC) • Wireless Power Transmission (WPT)

<table>
<tr><th>Core</th><th>Supportive</th><th>Elective</th></tr>
<tr><td>

Analogue Signal Processing
Digital Signal Processing
Digital Signal Processors
Analogue and Digital Electronics
Integrated Electronics
Optoelectronics
Non-Linear Devices
Electrical and Electronic Circuit Analysis and Design
Microprocessors
Digital Logic Design and Microcontrollers
Information Theory
Source Coding and Channel Coding
Communication Channels and Models
Analogue and Digital Communications
Optical Fibre Communication
MillimetreWave Communication
Radar and Satellite Communication

<u>Mobile and Wireless Communications</u>

Spectrum Management and frequency planning
Electromagnetic waves
Cellular and Radio Systems
Antennas

<u>Computer and Data Networks</u>

Wire and Wireless Networks

</td><td>

Development Studies
Sociology (and Gender)
Basic Economics

Law and Professional Practice

Law, Ethics, Integrity and Professional Practice

</td><td></td></tr>
</table>

Core	Supportive	Elective
• Local and Wide Area Networks • Networks Programming • Programming of Services • Network Security • Data Communications • Multimedia Systems • Image and Video Communications • Queuing Theory • Transmission Aspects of Voice Telephony • Transmission and Switching • Quality of Service and Telecommunication Impairments **Engineering Analysis, Design and Manufacturing** • Computer Aided Engineering Analysis and Design *(including CAD Tools)* • Design Project **Experiential Learning** • Workshop Practice • Industrial Training • Problem Based Learning (PBL) Project **Engineering Management and Economics** • Electronics and Telecommunication Engineering Management *(including project management)* • Engineering Economics		

Core	Supportive	Elective
• Entrepreneurship *(including marketing)* **Engineering Research** • Research Methodology • Research Project **Environmental Management and Sustainability** Environmental Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)*		

4.4.6 ELOS AND THE ALIGNMENT MATRIX

The learner is expected to demonstrate clearly the knowledge they have acquired after going through the full electronics and telecommunication engineering training programme. It is expected that a learner will be able to exhibit sound grasp of science, mathematics and other related subjects, and the learner should have an understanding of the profession and its ethical responsibilities. The proceeding Table 4.12 presents an alignment of the ELOs (see Table 4.1) and the minimum courses / subject areas (see Table 4.2) for a bachelor's in civil engineering programme.

4.4.7 EXPERIENTIAL LEARNING AND PROJECT WORK

For a Bachelor's in Electronics and Telecommunication Engineering programme, the experiential learning and project work benchmarking are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

4.4.8 TEACHING, LEARNING AND ASSESSMENT

For a Bachelor's in Electronics and Telecommunication Engineering programme, teaching, learning and assessment are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

Table 4.12: Alignment Matrix for a Bachelor's in Electronics and Telecommunication Engineering Programme's ELOs and Minimum Courses / Subject Areas

S/No.	Course / Subject Area	Expected Learning Outcomes																											
		Knowledge					Skills																		Attitude				
							Cognitive							Practical								Interpersonal							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
CORE COURSES / SUBJECT AREAS																													
	Basic Engineering																												
1	Introduction to Electronics and Telecommunication Engineering	√	√	√		√		√		√					√						√		√	√	√	√		√	√
2	Principles of Electrical Engineering	√	√	√	√			√		√		√		√			√			√			√	√	√	√			√
3	Fluids Mechanics	√	√	√			√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
4	AC Fundamentals	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
5	Strength of Materials	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
6	DC Network Theorems	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
7	Mechanics for Electrical Engineers	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
8	Engineering Drawing	√	√	√	√		√	√		√	√			√	√		√	√	√	√		√	√	√	√	√			√
9	Electrical Drawing *(including CAD)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Fundamentals																												
10	Electrical Network Analysis	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
11	Electromagnetic Fields	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
12	Electrical Measurement and Instrumentation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
13	Electrical Circuit Theory (ECT)	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
14	Electrical DC Machines	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
15	Electrical AC Machines and Transformers	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
16	Electrostatics and Electrodynamics	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
17	Signals and Systems: Control Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
18	Analogue and Digital Electronics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
19	Analogue Signal Processing	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
20	Power Electronics and Drives	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
21	Digital Signal Processing	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
22	Digital Signal Processors	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
23	Integrated Electronics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
24	Optoelectronics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
25	Electrical and Electronic Circuit Analysis and Design	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
26	Non-Linear Devices	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
27	Microprocessors	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
28	Digital Logic Design and Microcontrollers	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

29	Information Theory	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
30	Source Coding and Channel Coding																												
31	Communication Channels and Models	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
32	Analogue and Digital Communication	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
33	Optical Fibre Communication	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
34	MillimetreWave Communication	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
35	Radar and Satellite Communication	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
36	Spectrum Management and Frequency planning	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
37	Electromagnetic Waves	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
38	Cellular and Radio Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
39	Antennas	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
40	Wire and Wireless Networks	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
41	Local and Wide Area Networks	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
42	Networks Programming	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
43	Programming of Services	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
44	Network Security	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
45	Data Communications	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
46	Multimedia Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
47	Image and Video Communications	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
48	Queuing Theory	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
49	Transmission Aspects of Voice Telephony	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
50	Transmission and Switching	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
51	Quality of Service and Telecommunication Impairments	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
52	Electrical Engineering Specifications, Standards and Codes of Practice	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
53	Industrial Health, Safety and Maintenance	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Analysis, Design and Manufacturing																												
54	Computer Aided Engineering Analysis and Design *(including CAD tools)*	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
55	Design Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Experiential Learning																												
56	Workshop Practice *(to include electrical and mechanical workshops)*	√	√	√	√	√					√		√	√	√		√		√	√	√	√	√	√	√	√	√	√	√
57	Industrial Training	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
58	Problem Based Learning (PBL) Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

	Engineering Research																												
59	Research Methodology	√	√	√	√			√				√			√	√		√				√	√	√	√	√	√	√	√
60	Research Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Environmental Management and Sustainability																												
61	Environmental Quality Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)*	√	√	√	√	√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Engineering Management and Economics																													
62	Electronics and Telecommunication Engineering Management *(including project planning and management)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
63	Engineering Economics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
64	Entrepreneurship *(including marketing)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
SUPPORTIVE COURSES / SUBJECT AREAS																													
	Basic Sciences																												
65	Physics for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
66	Chemistry for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
	Mathematics for Engineers																												
67	Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Numerical Methods and Vector Analysis)*	√	√	√	√							√										√	√	√	√	√			√
	Programming																												
68	Computer Fundamentals and ICT	√	√	√	√	√		√	√	√	√				√		√	√			√	√	√	√	√	√	√	√	√
69	Programming for Engineers *(including languages)*	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
70	Database Systems	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
	Probability and Statistics																												
71	Probability and Statistics for Engineers	√	√	√	√	√		√				√						√				√		√	√	√	√	√	√
	Writing and Communication																												
72	Communication Skills for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
73	Technical Writing for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
	Basic Social Sciences and Humanities																												
74	Development Studies	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
75	Sociology *(including gender)*	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
76	Basic Economics	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
	Law and Professional Practice																												
77	Law, Ethics, Integrity and Professional Practice	√	√	√	√	√	√	√					√						√	√	√	√	√	√	√	√	√	√	√

ELECTIVES COURSES / SUBJECT AREAS																													
1	Embedded Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2	Artificial Intelligence	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3	Machine Learning	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4	Robotics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
5	Wireless Sensor Networks	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
6	Internet of Things (IoT)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
7	Nano and Micro Electronics	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
8	High-Speed Transmissions and Applications	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
9	Mobile Application Development	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
10	PowerLine Communication (PLC)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
11	Wireless Power Transmission (WPT)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

4.5 Benchmarks for a Bachelor's in Agricultural Engineering Programme

4.5.1 DESCRIPTION OF AGRICULTURAL ENGINEERING

Agricultural engineering deals with design, analytical and managerial skills that use engineering principles for solving problems in agriculture systems for improved production and productivity. Traditionally, the sub-fields of agricultural engineering constitute areas in irrigation and water resources engineering, bioprocess and post-harvest engineering, land use planning and management, farm power, machinery and mechanisation, farm structures and environmental engineering.

4.5.2 AGRICULTURAL ENGINEERING PROGRAMME GOAL

The goal of a bachelor's in agricultural engineering programme is to afford a learner knowledge, skills and competence in civil engineering.

4.5.3 PROGRAMME OBJECTIVES

The objectives of a bachelor's in agricultural engineering programme may be grouped into three categories; namely; academic ability, employability and personal development, as elaborated in the following sub-sections.

4.5.3.1 Academic Ability

The programme objectives under this category are to:

- Equip learners with knowledge and skills for solving agricultural engineering problems;
- Prepare learners to engage in professional practice in industry, government and academia;
- Equip learners with the ability to undertake innovative design, research and implementation of products and services in the field of agricultural engineering, and to progress to higher levels of studies in agricultural engineering; and
- Engage in life-long learning in the field of Agricultural Engineering.

4.5.3.2 Employability

The programme objectives under this category are to:

- Equip learners with knowledge and skills that enable creativity, innovativeness, management and entrepreneurship in the field of agricultural engineering;

- Prepare learners to have right attitude to work, team work and ability to communicate effectively;
- Equip learners with up-to-date agricultural engineering skills for the industry;
- Equip learners with analytical skills to understand the impacts of agricultural engineering on individuals, organisations and society; and
- Equip learners with the ability to integrate theory and practice to work effectively and efficiently in organisations.

4.5.3.3 Personal Development

The programme objectives under this category are to:

- Impart professional ethics and integrity to learners;
- Prepare learners for life-long learning and research;
- Empower learners to progress in their personal carrier;
- Equip the learner with skills and attitude to work in multicultural and global environments;
- Equip the learner with knowledge and skills to work as a team in the Agricultural Engineering field; and
- Enable the learner to develop skills to perform effectively in technical and non-technical environments.

4.5.4 EXPECTED LEARNING OUTCOMES

A learner completing a bachelor's in agricultural engineering programme should be able to demonstrate the attributes, knowledge, skills and attitude highlighted in Sections 3.4 and 3.5. A tabulation of Expected Learning Outcomes (ELOs) is provided in Table 4.13 below. The ELOs are categorised into knowledge, skills (cognitive, practical and interpersonal), and attitude and linked to the graduate attributes, following modification of the generic ELOs in Table 3.1.

Table 4.13: ELOs for a Bachelor's in Agricultural Engineering Programme (*Each ELO is linked to the graduate attributes in Section 3.4)*

Knowledge	
	The graduate should be able to: 1. Demonstrate a critical understanding of principles, theories, concepts, and facts relevant to the practice of Agricultural Engineering (viii) 2. Demonstrate understanding of science, mathematics and technological advancement relevant to Agricultural Engineering (iv) 3. Demonstrate understanding of the impact of Agricultural Engineering solutions in a global and societal context (vi) 4. Demonstrate awareness of relevant contemporary issues (vi) 5. Explain basic concepts in business, public policy, management and leadership (vi, vii)
Skills	
Cognitive skills	***The graduate should be able to:*** 6. Design a system, component or process for varied problems in Agricultural Engineering to meet desired needs including economic, environmental, social, ethical, health and safety, manufacturability, and sustainability, and understand limitations of the solutions (viii) 7. Interpret data, and draw valid conclusions for Agricultural Engineering related problems and sustainable infrastructure development (viii) 8. Write computer programmes relevant to Agricultural Engineering (viii) 9. Evaluate designs and propose appropriate improvements (viii) 10. Demonstrate creativity and innovativeness in solving Agricultural Engineering problems (iii, viii) 11. Analyse results of numerical models and appreciate their limitations (viii) 12. Manage projects, resources and time considering legal and statutory requirements, health and safety, quality, risk, reliability and sustainability (vi, vii, viii)

Practical Skills	***The graduate should be able to:*** 13. Prepare and interpret technical drawings (i, viii) 14. Prepare technical reports and deliver technical presentations (i, viii) 15. Undertake field investigations, laboratory work, and analyse data for use in planning and design (viii) 16. Undertake basic practical work, supervision and inspection of Agricultural Engineering work (ii, vii, viii) 17. Use relevant computer applications in solving Agricultural Engineering problems (i, iii, viii) 18. Apply relevant specifications, standards and Codes of Practice (i, v) 19. Prepare and use project documentation (including specifications, plans, maps and drawings) (i, ii, viii) 20. Demonstrate entrepreneurial acumen to develop and sustain an enterprise and improve livelihood (iii, vi, vii)
Interpersonal Skills	***The graduate should be able to:*** 21. Demonstrate leadership skills in the work environment (vii, viii) 22. Demonstrate ability to work and interact in multicultural, multidisciplinary and other diverse environments (ii, vii) 23. Work effectively in a team (vii)
Attitude	
	The graduate should be able to: 24. Demonstrate commitment to life-long learning, continuous self and professional development and/or pursue graduate study and recognise its importance (ix) 25. Demonstrate an inquisitive mind, eager for new knowledge and understanding (iii, ix) 26. Empathise with stakeholders (iv, vi) 27. Uphold high moral standards in relation to professional conduct and apply appropriate ethical principles in practices (v) 28. Show self-awareness and ability to adapt to new situations (iii, ix)

4.5.5 TRANSLATING THE ELOS INTO THE PROGRAMME

Table 4.14 below indicates the minimum courses / subject areas for a bachelor's in agricultural engineering programme; categorised into core, supportive and elective courses under the clusters pre-defined in Table 3.2. The minimum courses / subject areas are evenly distributed across the main thematic areas of agricultural engineering.

Table 4.14: Minimum Courses / Subject Areas for a Bachelor's in Civil Engineering Programme

Core	Supportive	Elective
Basic Engineering • Introduction to Agricultural Engineering • Engineering Drawing • Fundamentals of Electrical and Mechanical Engineering • Fluid Mechanics • Engineering Hydraulics • Strength of Materials • Engineering Mechanics • Thermodynamics for Engineers • Mechanics of Machines • Materials Science and Engineering **Engineering Fundamentals** • Measurement and Instrumentation • Engineering Properties of Biological Materials • Engineering Surveying • Soil Mechanics • Electrical Power Systems and Machines • Renewable Energy Resources and Technologies	**Basic Sciences** • Physics for Engineers • Chemistry for Engineers • Introduction to Animal Production • Extension Methods • Agricultural Biometry • Introduction to Crop Production • Microbiology for engineers *(including Food aspects and Environment)* **Mathematics for Engineers** • Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Laplace Transforms, Fourier series, Numerical Methods, Vector Analysis)* **Programming** • Programming for Engineers	• Water Supply • Rainwater Harvesting Systems • Drainage and Land Reclamation • Specific Crop Processing • Controlled Environment Production Systems • Process and Plant Design • Fluid Power and Hydraulic Systems • Earth Moving Equipment • Sensors and Controls for Precision Agriculture • Design of Water Reservoirs and Small Dams • Perishable Produce Storage and

Core	Supportive	Elective
• Waste Management • Ergonomics, Safety and Maintenance • Farm Planning and Construction of Farm Structures • Principles of Hydrology • Water Resources Engineering and Management • Land Evaluation and Land use Planning • GIS and Remote Sensing • Soil and Water Conservation • Design and Analysis of Farm Structures • Design of Irrigation and Drainage Systems • Agricultural Machinery Design • Agricultural Machinery and Equipment • Farm Implements, Operation and Maintenance • Irrigation and Drainage Management • Agricultural Produce Storage, Packaging and Transport • Agricultural Machinery Management • Thermal Processing of Biological Materials • Mechanical Processing of Biological Materials **Engineering Analysis, Design and Manufacturing**	*(including languages)* • Computer Fundamentals and ICT **Probability and Statistics** • Probability and Statistics for Engineers **Writing and Communication** • Technical Writing for Engineers • Communication Skills for Engineers **Basic Social Sciences and Humanities** • Development Studies • Sociology *(and Gender)* • Basic Economics **Law and Professional Practice** • Law, Ethics, Integrity and Professional Practice	Processing • Design and Installation of Renewable Energy Systems

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

4.5.6 ELOS AND THE ALIGNMENT MATRIX

The learner is expected to demonstrate clearly the knowledge they have acquired after going through the full agricultural engineering training programme. It is expected that a learner will be able to exhibit sound grasp of science, mathematics and other related subjects, and the learner should have an understanding of the profession and its ethical responsibilities. The proceeding Table 4.15 presents an alignment of the ELOs (see Table 4.1) and the minimum courses / subject areas (see Table 4.2) for a bachelor's in civil engineering programme.

4.5.7 EXPERIENTIAL LEARNING AND PROJECT WORK

For a Bachelor's in Agricultural Engineering programme, the experiential learning and project work benchmarking are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

4.5.8 TEACHING, LEARNING AND ASSESSMENT

For a Bachelor's in Agricultural Engineering programme, the teaching, learning and assessment are discussed in Section 3.9 of Part 3; applicable to any bachelor's in engineering programme.

Table 4.15: Alignment Matrix for a Bachelor's in Agricultural Engineering Programme's ELOs and Minimum Courses / Subject Areas

S/No.	Course / Subject Area	Expected Learning Outcomes																											
		Knowledge					Skills																		Attitude				
							Cognitive							Practical								Interpersonal							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
CORE COURSES / SUBJECT AREAS																													
	Basic Engineering																												
1	Introduction to Agricultural Engineering	√	√	√		√		√		√					√						√		√	√	√	√		√	√
2	Fundamentals of Electrical and Mechanical Engineering	√	√	√	√			√		√		√		√			√			√			√	√	√	√			√
3	Fluids Mechanics	√	√	√			√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
4	Engineering Hydraulics	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
5	Strength of Materials	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
6	Engineering Mechanics	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
7	Engineering Drawing	√	√	√	√		√	√		√	√			√	√		√	√	√	√		√	√	√	√	√			√
8	Thermodynamics for Engineers	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
9	Mechanics of Machines	√	√	√	√		√	√		√		√		√	√	√	√	√	√	√		√	√	√	√	√			√
10	Materials Science and Engineering	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
	Engineering Fundamentals																												
11	Measurement and Instrumentation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
12	Engineering Properties of Biological Materials	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
13	Electrical Power Systems and Machines	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
14	Renewable Energy Resources and Technologies	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
15	Soil Mechanics	√	√	√	√		√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√	√		√
16	Principles of Hydrology	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√		√	√	√	√	√			√
17	Waste Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
18	Engineering Surveying	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
19	GIS and Remote Sensing	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
20	Ergonomics, Safety and Maintenance	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
21	Water Resources Engineering and Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
22	Farm Planning and Construction of Farm Structures	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
23	Land Evaluation and Land use Planning	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
24	Soil and Water Conservation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
25	Design and Analysis of Farm	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

	Structures																												
26	Design of Irrigation and drainage Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
27	Agricultural Machinery Design	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
28	Agricultural Machinery and Equipment	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
29	Farm Implements, operation and maintenance	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
30	Irrigation and Drainage Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
31	Agricultural Produce Storage, Packaging and Transport	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
32	Agricultural Machinery Management	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
33	Thermal Processing of Biological Materials	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
34	Mechanical Processing of Biological Materials	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
35	Farm Planning and Construction of Farm Structures	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Analysis, Design and Manufacturing																												
36	Computer Modelling and Simulation	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
37	Computer Aided Design and Manufacturing (CAD / CAM)	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
38	Engineering Design	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
39	Design Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Experiential Learning																												
40	Workshop Practice	√	√	√	√	√					√		√	√	√		√		√	√	√	√	√	√	√	√	√	√	√
41	Industrial Training	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
42	Problem Based Learning (PBL) Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Research																												
43	Research Methodology	√	√	√	√			√				√			√	√		√				√	√	√	√	√	√	√	√
44	Research Project	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Environmental Management and Sustainability																												
45	Environmental Quality Management and Sustainability *(including ESIA, EIA, EA, and Health and Safety Practice)*	√	√	√	√	√	√	√		√	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
	Engineering Management and Economics																												
44	Agricultural Engineering Management *(including project planning and management)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
45	Engineering Operations Management (Operations Research)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
46	Agribusiness and Entrepreneurship *(including marketing)*	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
SUPPORTIVE COURSES / SUBJECT AREAS																													
	Basic Sciences																												

47	Physics for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
48	Chemistry for Engineers	√	√	√	√											√	√					√	√	√	√	√			√
49	Introduction to Animal Production	√	√	√	√											√	√					√	√	√	√	√			√
50	Extension Methods	√	√	√	√											√	√					√	√	√	√	√			√
51	Agricultural Biometry	√	√	√	√											√	√					√	√	√	√	√			√
52	Introduction to Crop Production	√	√	√	√											√	√					√	√	√	√	√			√
53	Microbiology for engineers *(including Food aspects and Environment)*	√	√	√	√											√	√					√	√	√	√	√			√
	Mathematics for Engineers																												
54	Mathematics for Engineers *(including Algebra, Calculus, Differential Equations, Linear Transformation and Matrices, Complex Analysis, Numerical Methods and Vector Analysis)*	√	√	√	√							√										√	√	√	√	√			√
	Programming																												
55	Computer Fundamentals and ICT	√	√	√	√	√		√	√	√	√				√		√	√			√	√	√	√	√	√	√	√	√
56	Programming for Engineers *(including languages)*	√	√	√	√	√	√	√	√	√	√	√			√		√	√			√	√	√	√	√	√	√	√	√
	Probability and Statistics																												
57	Probability and Statistics for Engineers	√	√	√	√	√		√				√						√				√		√	√	√	√	√	√
	Writing and Communication																												
58	Communication Skills for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
59	Technical Writing for Engineers	√	√	√	√	√		√		√		√			√		√	√	√	√	√	√	√	√	√	√	√	√	√
	Basic Social Sciences and Humanities																												
60	Development Studies	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
61	Sociology *(including gender)*	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
62	Basic Economics	√	√	√	√	√		√		√	√	√	√			√					√	√	√	√	√	√	√	√	√
	Law and Professional Practice																												
63	Law, Ethics, Integrity and Professional Practice	√	√	√	√	√	√	√					√						√	√	√	√	√	√	√	√	√	√	√
ELECTIVES COURSES / SUBJECT AREAS																													
1	Water Supply	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2	Rainwater Harvesting Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3	Drainage and Land Reclamation	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
4	Specific Crop Processing	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
5	Controlled Environment Production Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
6	Process and Plant Design	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
7	Fluid Power and Hydraulic Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
8	Earth Moving Equipment	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
9	Sensors and Controls for Precision Agriculture	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
10	Design of Water Reservoirs and Small Dams	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

11	Perishable Produce Storage and Processing	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
12	Design and Installation of Renewable Energy Systems	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Inter-University Council for East Africa
Plot M833, Kigobe Road Kyambogo, Kampala
P. O. Box 7110 Kampala, Uganda
Tel: +256-414-256251/2 Fax: +256-414-342007
E-mail: info@iucea.org Website: www.iucea.org