UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

COLLEGE OF AGRICULTURE, ENGINEERING AND SCIENCE

SCHOOL OF ENGINEERING

MECHANICAL ENGINEERING

ECSA GRADUATE ATTRIBUTES

QUALITY ASSURANCE FORM 14 (QA14)

1. GRADUATE ATTRIBUTE REPORT

Document No. : E-02-PE, Revision 7 **Qualification Standard for Bachelor of Science in Engineering (BSc(Eng))/ Bachelors of Engineering (BEng): NQF Level 8.** ***Section 15 p.16-24***

1.1. Graduate Attribute 1 – Problem Solving

Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences with holistic considerations for sustainable development.

Question to be answered	Has the student identified, formulated, analysed and solved a complex engineering problem creatively and innovatively on page 5
Types of evidence	• Identification and refinement of ill-posed or under/over -specified problems, involving wide-ranging or conflicting issues. • Contextualisation of problem in terms of literature, global economic and technological trends, government imperatives, significance to society, etc. • Solving problems that consist of sub-problems or involving infrequently encountered or unfamiliar issues. • Solutions have these characteristics: are not obvious, require originality or analysis based on fundamentals, require information from a variety of sources.

1.2. Graduate Attribute 2 – Application of scientific and engineering knowledge

Apply knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialisation to develop solutions to complex engineering problems.

Question to be answered	Has the student applied knowledge of mathematics, natural sciences, engineering fundamentals and an engineering speciality to solve complex engineering problems on page 5?
Types of evidence	• Mathematics, natural science and engineering sciences are applied in formal analysis and modelling of engineering situations, and for reasoning about and conceptualising engineering problems. • A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences. • Conceptually based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline. • A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline. • Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline, much of which is at the forefront of the discipline.

1.3. Graduate Attribute 3 – Engineering design

Design creative solutions for complex engineering problems and design systems, components or processes to meet identified needs.

Question to be answered	Has the student demonstrated competence to performed creative, procedural and non-procedural design and synthesis of components, systems, engineering works, products or processes?
Types of evidence	• Design problems used in exit-level assessment must conform to the definition of a complex engineering problem. • A major design problem should be used to provide evidence. • The design knowledge base and components, systems, engineering works, products or processes to be designed are dependent on the discipline or practice area. • The use of formal engineering design procedures and methods for the design of components, systems or processes. The use of formal concept generation and selection tools and methods. • The use of design tools, e.g. QFD etc. • The documentation of designs using CAD, function breakdown diagrams and assembly precedence diagrams.

	• The application of Design for X principles. • Appropriate consideration must be given to public health and safety, whole-life cost and net zero carbon, as well as resource, cultural, societal and environmental considerations, as required.

1.4. Graduate Attribute 4 – Investigations, experiments and data analysis

Demonstrate competence to conduct investigations of complex engineering problems using research methods, including research-based knowledge, design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

Question to be answered	Has the student demonstrated competence to design and conduct investigations and experiments?
Types of evidence	• Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues. • The balance of investigation and experiment should be appropriate to the discipline. • Research methodology is to be applied in research or an investigation where the student engages with selected knowledge in the research literature of the discipline.

1.5. Graduate Attribute 5 – Use of engineering tools

Demonstrate competence to create, select and apply and recognise limitations of appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling, to complex engineering problems.

Question to be answered	Has the student demonstrated competence to use appropriate engineering methods, skills and tools, including those based on IT?
Types of evidence	• Use of discipline-specific tools, processes or procedures. • Use of computer packages for computation, modelling, simulation, and information handling (e.g. CAD, FEA, CFD, MATLAB, Mathematica, etc.). • Use of computers, networks and information infrastructures to enhance personal productivity and teamwork. • Conceptually based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline. • Knowledge of engineering practice (technology) in the practice areas in the engineering discipline. • A range of techniques, resources and modern engineering and IT tools appropriate to the disciplinary designation of the programme

1.6. Graduate Attribute 6 – Professional and technical communication

Demonstrate competence to communicate effectively and inclusively on complex engineering activities, both orally and in writing, with the engineering community and society at large, taking into account cultural, language, and learning differences.

Question to be answered	Has the student demonstrated competence to communicate effectively in writing and orally?
Types of evidence	• Conventional methods of the discipline (e.g. CAD Drawings). • Subject-specific communication methods (e.g. Graphical Techniques). • Logical construction of dissertation. • Professional and concise written communication. • Use of appropriate technical terminology. • Competent use of grammar, spelling and punctuation. • Use of formal referencing standards. • Ethical conduct in the use of reference materials

1.7. Graduate Attribute 7 – The engineer and the world

Demonstrate critical awareness of the sustainable development impacts on society, the economy, sustainability, health and safety, legal frameworks and the environment.

Question to be answered	Has the student demonstrated critical awareness of the sustainability and impact of engineering activity on the social, industrial and physical environment?
Types of evidence	• The combination of social, workplace (industrial) and physical environmental factors must be appropriate to the discipline or other designation of the qualification. • Comprehension of the role of engineering in the world and identified issues in engineering practice in the discipline: health, safety and environmental protection, risk assessment and management, and the impacts of engineering activity: economic, social, cultural, environmental and sustainability. • Identifying issues in engineering design that relate to health, safety, environmental protection, risk assessment and management. • Analysing the sustainability and impact of engineering designs on the economic, social, cultural, environmental domains.

	• A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences. • Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon and similar concepts, that supports engineering design and operations in a practice area. • Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

1.8. Graduate Attribute 8 – Individual and collaborative teamwork	
Demonstrate competence to function effectively as an individual and as a member or leader in diverse and inclusive teams, and in multi-disciplinary, face-to-face, remote and distributed settings.	
Question to be answered	Has the student demonstrated competence to work effectively as an individual, in teams and in multidisciplinary environments?
Types of evidence	• Multi-disciplinary tasks require co-operation across at least one disciplinary boundary. • Co-operating disciplines may be engineering disciplines with different fundamental bases other than that of the programme or may be outside engineering. • The work of each group member is coherent with work of other team members. • There is a clear distinction between the work done by individuals and that of the group as a whole. • Student has made an appropriate individual contribution to the project. • Multidisciplinary work with professionals outside of the discipline of mechanical engineering have provided significant technical insights

1.9. Graduate Attribute 9 – Independent learning ability	
Demonstrate competence to engage in independent learning through well-developed learning skills.	
Question to be answered	Has the student demonstrated competence to engage in independent learning through well-developed learning skills?
Types of evidence	• Operating independently in complex, ill-defined contexts requiring personal responsibility and initiative. • Insightful engagement with literature from advanced academic sources. • Acquisition and application of new knowledge, skills and insights outside of formal instruction and without direct supervision. • Awareness of social and ethical implications of applying knowledge in particular contexts. • Operate independently in complex contexts recognising the need for and having the preparation and ability for i. independent and life-long learning, ii. adaptability to new and emerging technologies, iii. critical thinking in the broadest context of technological change.

1.10. Graduate Attribute 10 – Engineering professionalism	
Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws.	
Question to be answered	Has the student demonstrated critical awareness of the need to act professionally and ethically and to exercise judgment and take responsibility within own limits of competence?
Types of evidence	• Knowledge of professional ethics, responsibilities and norms of engineering practice. • Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

1.11. Graduate Attribute 11 – Project management and finance	
Demonstrate knowledge and understanding of engineering management principles and economic decision-making.	
Question to be answered	Has the student demonstrated knowledge and understanding of engineering management principles and economic decision-making?
Types of evidence	• Application of basic techniques from economics, business management and project management applied to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments. • Critical reflection on individual and group progress. • Critical reflection on individual and group management practice during engineering activities. • Critical reflection and evaluation of achievements, outputs, measures of success and stakeholder satisfaction. • Use of project management tools: Gantt or PERT charts, meeting minutes, organograms, responsibility matrices, budgets, budget performance reports, etc.

GRADUATE ATTRIBUTES

[Document No.:E-02-PE. Revision No.: 7. Qualification Standard for Bachelor of Science in Engineering Bachelor of Engineering: NQF Level 8. Section 15 p.16-24]

The Graduate Attributes defined below are stated generically and may be assessed in various engineering disciplinary or cross disciplinary contexts in a provider based or simulated practice environment. Words and phrases having specific meaning are defined in this document and in ECSA document E01 POL.
General range statement:
The competencies defined in the 11 graduate attributes may be demonstrated in a university based, simulated workplace context. Competencies stated generically may be assessed in various engineering disciplinary or cross disciplinary contexts.
Complex engineering problems
a) These require a fundamentals-based, first principles analytical approach, use in-depth engineering knowledge and have one or more of the following characteristics:
i. A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
ii. Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much of which is at the forefront of the discipline.
iii. Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
iv. Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
v. Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
b) and have some or all of the following characteristics:
i. Involve wide-ranging and/or conflicting technical, non-technical issues (such as ethical, sustainability, legal, political, economic, societal) and consideration of future requirements.
ii. Have no obvious solution and require abstract thinking, creativity and originality in analysis to formulate suitable models.
iii. Involve infrequently encountered issues or novel problems.
iv. Address problems not encompassed by standards and codes of practice for professional engineering.
v. Involve collaboration across engineering disciplines, other fields, and/or diverse groups of stakeholders with widely varying needs.
vi. Address high-level problems with many components or sub-problems that may require a systems approach.
Graduate Attribute 1: Problem-solving
Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences with holistic considerations for sustainable development.
Associated knowledge and attitude profile:
• A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
• Conceptually based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
• A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
• Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline, much of which is at the forefront of the discipline.

Graduate Attribute 2: Application of scientific and engineering knowledge

Apply knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialisation to develop solutions to complex engineering problems.

Associated knowledge and attitude profile:

- A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
- Conceptually based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
- A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
- Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline, much of which is at the forefront of the discipline.

Range statement:

Mathematics, natural science and engineering sciences are applied in formal analysis and modelling of engineering situations, and for reasoning about and conceptualising engineering problems.

Graduate Attribute 3: Engineering design

Design creative solutions for complex engineering problems and design systems, components or processes to meet identified needs.

Associated knowledge and attitude profile:

Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon and similar concepts, that supports engineering design and operations in a practice area.

Range statement:

Design problems used in exit-level assessment must conform to the definition of a complex engineering problem. A major design problem should be used to provide evidence. The design knowledge base and components, systems, engineering works, products or processes to be designed are dependent on the discipline or practice area. Appropriate consideration must be given to public health and safety, whole-life cost and net zero carbon, as well as resource, cultural, societal and environmental considerations, as required.

Graduate Attribute 4: Investigations, experiments and data analysis

Demonstrate competence to conduct investigations of complex engineering problems using research methods, including research-based knowledge, design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

Associated knowledge and attitude profile:

- Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

Range statement:

The balance of investigation and experiment should be appropriate to the discipline. Research methodology is to be applied in research or an investigation where the student engages with selected knowledge in the research literature of the discipline.

Note:

An investigation differs from a design in that the objective is to produce knowledge and understanding of a phenomenon and a recommended course of action rather than specifying how an artefact can be produced.

Graduate Attribute 5: Use of engineering tools

Demonstrate competence to create, select and apply and recognise limitations of appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling, to complex engineering problems.

Associated knowledge and attitude profile:

- Conceptually based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
- Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

Range statement:

A range of techniques, resources and modern engineering and IT tools appropriate to the disciplinary designation of the programme.

Graduate Attribute 6: Professional and technical communication

Demonstrate competence to communicate effectively and inclusively on complex engineering activities, both orally and in writing, with the engineering community and society at large, taking into account cultural, language, and learning differences.

Range statement:

Material to be communicated is in an academic or simulated professional context. Audiences range from engineering peers, management and lay persons, using appropriate academic or professional discourse. Written reports range from short (300 to 1 000 words, plus tables and diagrams) to long (10 000 to 15 000 words plus tables, diagrams and appendices), covering material at exit-level. Methods of providing information include the conventional methods of the discipline, for example engineering drawings and design documentation, as well as subject-specific methods.

Graduate Attribute 7: The engineer and the world

Demonstrate critical awareness of the sustainable development impacts on society, the economy, sustainability, health and safety, legal frameworks and the environment.

Associated knowledge and attitude profile:

- A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
- Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon and similar concepts, that supports engineering design and operations in a practice area.
- Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

Range statement:

The combination of social, workplace (industrial) and physical environmental factors must be appropriate to the discipline or other designation of the qualification. Comprehension of the role of engineering in the world and identified issues in engineering practice in the discipline: health, safety and environmental protection, risk assessment and management, and the impacts of engineering activity: economic, social, cultural, environmental and sustainability.

Developmental considerations:

- Ability to self-reflect and show contextual awareness of social, workplace and governmental environments through exposure to complex, multi-disciplinary and/or unfamiliar problems.
- Ability to identify and position a design/artefact in the bigger picture and use appropriate judgement (intentionally incorporate multiple perspectives) to obtain a final solution or product.
- Ability to listen and interpret information from a variety of stakeholders to appropriately position identified problems/challenges/opportunities in the relevant context.

Graduate Attribute 8: Individual and collaborative teamwork

Demonstrate competence to function effectively as an individual and as a member or leader in diverse and inclusive teams, and in multi-disciplinary, face-to-face, remote and distributed settings.

Associated knowledge and attitude profile:

- Knowledge of professional ethics, responsibilities and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Range statement:

Multi-disciplinary tasks require co-operation across at least one disciplinary boundary. Co-operating disciplines may be engineering disciplines with different fundamental bases other than that of the programme or may be outside engineering.

Developmental considerations:

- Develop the ability to self-reflect and self-evaluate within an interpersonal engagement towards enabling appropriate understanding of self and other team members.
- Develop the ability to listen and interpret different motivations, personalities or workstyles within a team context towards enabling functional team dynamics.
- Knowledge of team cohesion and dynamics, motivational styles, frameworks for conflict and tension resolution and the ability to apply these.

- Ability to negotiate and manage time and project components related to interpersonal needs and agendas. Time management also includes understanding the value of time, and determining if a task is better (cheaper) achieved by a single person or a team.

Graduate Attribute 9: Independent learning ability

Demonstrate competence to engage in independent learning through well-developed learning skills.

Associated knowledge and attitude profile:

Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

Range statement:

Operate independently in complex contexts recognising the need for and having the preparation and ability for

i) independent and life-long learning,

ii) adaptability to new and emerging technologies, and

iii) critical thinking in the broadest context of technological change.

Developmental considerations:

- Openness to constructive feedback, awareness of own limitations, ability to cope with the discomfort of uncertainty and having access to a range of approaches, reflective self-evaluation, curiosity and proactive engagement, resilience, confidence to ask for help and draw from a broad range of stakeholders.
- Reflection of self-learning to begin to recognise if what has been covered meets the needs of the activity or task.

Graduate Attribute 10: Engineering professionalism

Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws.

Associated knowledge and attitude profile:

- Knowledge of professional ethics, responsibilities and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Range statement:

Evidence includes case studies typical of engineering practice situations in which the graduate is likely to participate. An understanding of the need for diversity and inclusion is required.

Developmental considerations:

- Self-management, professional responsibility and awareness of expertise and limitations, good judgement, process of on-going self-reflection and evaluation.
- Timeous, clear, realistic communication of risks and concerns and feedback on progress.
- Self-efficacy, accepting feedback and consequences and commitment.

Graduate Attribute 11: Project management and finance

Demonstrate knowledge and understanding of engineering management principles and economic decision-making.

Range statement:

Basic techniques from economics and project management applied to one's own work, as a member and leader in a team, and to manage projects in multi-disciplinary environments.