ENGINEERING COUNCIL OF SOUTH AFRICA *Standards and Procedures System*		
Whole Qualification Standard for Bachelor of Science in Engineering (BSc(Eng))/ Bachelors of Engineering (BEng): NQF Level 7		
Authorised by Council. **Registered on the National Qualifications Framework: NLRD no 48694**		
Document : PE-61	**Rev-2**	**26 July 2004**

1. **FIELD:** Manufacturing, Engineering and Technology
2. **SUBFIELD:** Engineering and Related Design
3. **NQF LEVEL:** 7
4. **CREDITS:** 560
5. **Acceptable titles:** Bachelor of Science in Engineering, Bachelor of Engineering, Baccalareus Ingeneriae.
6. **Abbreviations:** BSc(Eng), BScEng, BEng, BIng.

7. Qualifiers

The qualification may have a disciplinary or cross-disciplinary qualifier (discipline, branch, option or endorsement) defined in the provider's rules for the degree and reflected on the academic transcript and degree certificate, subject to the following:

1. The designation must contain the word "Engineering". The qualifier may contain, one or combinations of the following descriptors: Agricultural, Aeronautical, Chemical, Civil, Computer, Electrical, Electro-mechanical Engineering Electronic, Environmental, Industrial, Extractive Metallurgy, Information, Materials, Mechanical, Mechatronics, Metallurgical, Mineral(s) Processing, Physical Metallurgy and Mining. Designations are not restricted to this list.
2. The qualifier must clearly indicate the nature and purpose of programme.
3. The fundamental engineering science content must be consistent with the qualifier.
4. The target market indicated by the qualifier may be a traditional branch of engineering or a substantial industry area;
5. In the case of a provider offering programmes with different designations but having only minor differences in content or undifferentiated purposes, only one programme should be accredited;
6. The designation should be comparable with typical programmes within Washington Accord countries;
7. BSc(Eng)/BEng/BIng programmes should not address narrow niche markets: formal education for such markets should rather be satisfied by broad undergraduate programmes such as specified in this standard followed by specialized course-based postgraduate programmes.

8. Rationale for the Qualification

Engineering is a discipline and profession that serves the needs of society and the economy. The Bachelors Degree in Engineering is designed to contribute to meeting this need by developing engineering competence. The qualification, with its broad fundamental base, is the starting point of a career path in one of many areas of engineering specialization through structured development and lifelong learning. The broad base allows maximum flexibility and mobility for the holder to adjust to changing needs. Skills, knowledge, values and attitudes reflected in the qualification are building blocks for the development of candidate engineers towards becoming competent engineers to ultimately lead complex engineering activities and solve complex engineering problems, thus contributing to economic activity and national development.

9. Purpose of the Qualification

The purpose of the qualification is to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a competent practicing engineer. The recognised purpose of the bachelors degree in engineering, designated BSc(Eng), BEng or BIng, accredited as satisfying this standard is to provide graduates with:

1. A thorough grounding in mathematics, basic sciences, engineering sciences, engineering modelling, and engineering design together with the abilities to enable applications in fields of emerging knowledge;
2. Preparation for careers in engineering and related areas, for achieving technical leadership and to make a contribution to the economy and national development;
3. The educational requirement towards registration as a Professional Engineer with the Engineering Council of South Africa as well as to allow the graduate to make careers in engineering and related fields;
4. For graduates with an appropriate level of achievement in the programme, the ability to proceed to postgraduate studies in both course-based and research masters programmes.

10. NQF Level, credits, minimum credits in knowledge areas

The programme leading to the qualification shall be a four-year full-time equivalent programme with a minimum of 560 SAQA credits. Not less than 120 Credits shall be at NQF level 7. The remaining credits shall be distributed in order to create a coherent progression of learning toward the exit level. Preparatory or remedial courses are not included in the 560 credits.

10.1 Knowledge profile of the graduate

The content of the programme when analysed by knowledge area shall not fall below the minimum SAQA credits in each knowledge area in table 1.

Knowledge areas are defined in Appendix A. The method for calculating credits and allocating to knowledge areas is defined in Appendix B.

Table 1: Minimum curriculum content by knowledge area

Knowledge area	Minimum Credits
Mathematical Sciences	56
Basic Sciences	56
Engineering Sciences	168
Design and Synthesis	67
Computing and IT	17
Complementary studies	56
Subtotal	420
Discretionary	≥140
Total Credits	≥560

The discretionary component shall be taken up by allocating knowledge to the six areas, to form a coherent, balanced programme.

Experiential training which is not quality assured by the provider, does not comprehensively assess student's performance against defined outcomes and is not documented and presented in the accreditation process shall not be assigned credits and included in the above breakdown.

10.2 Core and specialist requirements

The programme shall have a *coherent core* of mathematics, basic sciences and fundamental engineering sciences that provides a viable platform for further studies and lifelong learning. The coherent core must enable development in a traditional discipline or in an emerging field. The coherent core embraces both *fundamental* and *core* elements as defined by SAQA.

A programme shall contain specialist engineering study at the exit level. Specialist study may lead to elective or compulsory credits. Specialist study may take on many forms including further deepening of a theme in the core, a new sub-discipline, or a specialist topic building on the core. It is recognized that the extent of specialist study is of necessity limited in view of the need to provide a substantial coherent core. Specialist study may take the form of compulsory or *elective* credits.

In the Complementary Studies area, the programme is expected to contain a balance of material under both parts (a) and (b) of the definition in appendix A, consistent with Exit Level Outcomes 6, 7 and 10.

10.3 Curriculum Content

This standard does not specify detailed curriculum content. The fundamental and specialist engineering science content must be consistent with the designation of the degree.

11. Access to Qualification

This standard is specified as a set exit level outcomes and overall distribution of credits. Providers therefore have freedom to construct programmes geared to different levels of preparedness of learners, other than those with the minimum assumed learning indicated in section 12, including:

- Use of access programmes for learners who do not meet the minimum learning requirements;
- Creating articulation paths from other qualifications.

12. Minimum Learning Assumed to be in Place

Designers of a 560 credit programme to meet the exit level outcomes and credit requirements defined in this standards assume that entrants are proficient in:

1. Mathematics at a level equivalent to Senior Certificate Higher Grade, C symbol.
2. Physical Science at a level equivalent to Senior Certificate Higher Grade, D symbol.
3. Reading, speaking and writing in the language of instruction and reading in English.

Note: These assumptions do not prescribe prerequisites. Sections 11 and 12 should be read together.

13. Exit Level Outcomes

Exit level outcomes defined below are stated generically and may be assessed in various engineering disciplinary or cross-disciplinary contexts in a provider-based or simulate practice environment. Words shown italicized have specific meaning defined in ECSA Document G-04 [1].

General Range Statement: The competencies defined in the ten exit level outcomes may be demonstrated in a university-based, simulated workplace context. Competencies stated generically may be assessed in various engineering disciplinary or cross-disciplinary contexts.

Exit level outcome 1: Problem solving

Learning outcome: Demonstrate competence to identify, assess, formulate and solve *convergent* and *divergent* engineering problems creatively and innovatively.

Associated Assessment Criteria

The candidate applies in a number of varied instances, a systematic problem solving method including:

1. Analyses and defines the problem, identifies the criteria for an acceptable solution;
2. Identifies necessary information and applicable engineering and other knowledge and skills;
3. Generates and formulates possible approaches to solution of problem;
4. Models and analyses possible solution(s);
5. Evaluates possible solutions and selects best solution;
6. Formulates and presents the solution in an appropriate form.

Range Statement: Problems requires identification and analysis. Some cases occur in unfamiliar contexts. Problems are both *concrete* and *abstract* and may involve uncertainty. Solutions are based on theory and evidence, together with judgement where necessary.

Exit level outcome 2: Application of scientific and engineering knowledge

Learning outcome: Demonstrate competence to apply knowledge of mathematics, basic science and engineering sciences from first principles to solve engineering problems.

Associated Assessment Criteria

The candidate:

1. Brings mathematical, numerical analysis and statistical knowledge and methods to bear on engineering problems by using an appropriate mix of:
   a) Formal analysis and modelling of engineering components, systems or processes;
   b) Communicating concepts, ideas and theories with the aid of mathematics;
   c) Reasoning about and conceptualising engineering components, systems or processes using mathematical concepts;
   d) Dealing with uncertainty and risk through the use of probability and statistics.
2. Uses physical laws and knowledge of the physical world as a foundation for the engineering sciences and the solution of engineering problems by an appropriate mix of:
   a) Formal analysis and modelling of engineering components, systems or processes using principles and knowledge of the basic sciences;
   b) Reasoning about and conceptualising engineering problems, components, systems or processes using principles of the basic sciences.
3. Uses the techniques, principles and laws of engineering science at a fundamental level and in at least one specialist area to:
   a) Identify and solve open-ended engineering problems;
   b) Identify and pursue engineering applications;
   c) Work across engineering disciplinary boundaries through cross disciplinary literacy and shared fundamental knowledge.

Range Statement: Knowledge is coherent and systematically organized, covering the fundamentals of the discipline, with depth in limited specialist area(s), informed by current developments. A coherent and critical understanding of fundamental principles and theories of a *discipline* is required. Understanding of emerging issues in specialist area(s). Application of knowledge requires recognition of boundaries and limitations of disciplines.

Note: Problems used for assessment may provide evidence in the application of one, two or all three categories of knowledge listed above.

Exit level outcome 3: Engineering Design

Learning outcome: Demonstrate competence to perform creative, *procedural* and *non-procedural* design and synthesis of components, systems, engineering works, products or processes.

Associated Assessment Criteria:

The candidate executes an acceptable design process encompassing the following:

1. Identifies and formulates the design problem to satisfy user needs, applicable standards, codes of practice and legislation;
2. Plans and manages the design process: focusses on important issues, recognises and deals with constraints;
3. Acquires and evaluates the requisite knowledge, information and resources: applies correct principles, evaluates and uses design tools;
4. Performs design tasks including analysis, quantitative modelling and optimisation;
5. Evaluates alternatives and preferred solution: exercises judgment, tests implementability and performs techno-economic analyses;
6. Assesses impacts and benefits of the design: social, legal, health, safety, and environmental;
7. Communicates the design logic and information.

Range Statement: A major design problem should be used to provide evidence. The problem would be typical of that which the graduate would participate in a typical employment situation shortly after graduation. The selection of components, systems, engineering works, products or processes to be designed is dependent on the discipline.

Exit level outcome 4: Investigations, experiments and data analysis

Learning outcome: Demonstrate competence to design and conduct investigations and experiments.

Associated Assessment Criteria:

The candidate executes an acceptable process including but not restricted to:

1. Plans and conducts investigations and experiments;
2. Conducts a literature search and critically evaluates material;
3. Performs necessary analyses;
4. Selects and uses appropriate equipment or software;
5. Analyses, interprets and derives information from data;
6. Draws conclusions based on evidence;
7. Communicates the purpose, process and outcomes in a technical report.

Range Statement: The balance of investigation and experiment should be appropriate to the discipline. An investigation or experimental study should be typical of those in which the graduate would participate in an employment situation shortly after graduation.

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.

Exit level outcome 5: Engineering methods, skills and tools, including Information Technology

Learning outcome: Demonstrate competence to use appropriate engineering methods, *skills* and tools, including those based on information technology.

Associated Assessment Criteria:

The candidate:

1. Uses method, skill or tool effectively by:
   a) Selecting and assessing the applicability and limitations of the method, skill or tool;
   b) Properly applying the method, skill or tool;
   c) Critically testing and assessing the end-results produced by the method, skill or tool.
2. Creates computer applications as required by the discipline.

Range Statement: A range of methods, skills and tools appropriate to the disciplinary designation of the program including:

1. Discipline-specific tools, processes or procedures;
2. Computer packages for computation, modelling, simulation, and information handling;
3. Computers and networks and information infrastructures for accessing, processing, managing, and storing information to enhance personal productivity and teamwork;
4. Basic techniques from economics, business management, and health, safety and environmental protection.

Exit level outcome 6: Professional and technical communication

Learning outcome: Demonstrate competence to communicate effectively, both orally and in writing, with engineering audiences and the community at large.

Associated Assessment Criteria:

The candidate executes effective written communication as evidenced by:

1. Uses appropriate structure, style and language for purpose and audience;
2. Uses effective graphical support;
3. Applies methods of providing information for use by others involved in engineering activity;
4. Meets the requirements of the target audience.

The candidate executes effective oral communication as evidenced by:

1. Uses appropriate structure, style and language;
2. Uses appropriate visual materials;
3. Delivers fluently;
4. Meets the requirements of the intended audience.

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 (300-1000 word plus tables 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, as well as subject-specific methods.

Exit level outcome 7: Impact of Engineering activity

Learning outcome: Demonstrate *critical awareness* of the impact of engineering activity on the social, industrial and physical environment.

Associated Assessment Criteria:

The candidate identifies and deals with an appropriate combination of issues in:

1. The impact of technology on society;
2. Occupational and public health and safety;
3. Impacts on the physical environment;
4. The personal, social, cultural values and requirements of those affected by engineering activity.

Range Statement: The combination of social, workplace (industrial) and physical environmental factor must be appropriate to the discipline or other designation of the qualification.

Exit level outcome 8: Individual, team and multidisciplinary working

Learning outcome: Demonstrate competence to work effectively as an individual, in teams and in multidisciplinary environments.

Associated Assessment Criteria:

The candidate demonstrates effective individual work by performing the following:

1. Identifies and focuses on objectives;
2. Works strategically;
3. Executes tasks effectively;
4. Delivers completed work on time.

The candidate demonstrates effective team work by the following:

1. Makes individual contribution to team activity;
2. Performs critical functions;
3. Enhances work of fellow team members;
4. Benefits from support of team members;
5. Communicates effectively with team members;
6. Delivers completed work on time.

The candidate demonstrates multidisciplinary work by the following:

1. Acquires a working knowledge of co-workers' discipline;
2. Uses a systems approach;
3. Communicates across disciplinary boundaries.

Range Statement: Tasks require co-operation across at least one disciplinary boundary. Disciplines may be other engineering disciplines or be outside engineering.

Exit level outcome 9: Independent learning ability

Learning outcome: Demonstrate competence to engage in independent learning through well developed learning skills.

Associated Assessment Criteria:

The candidate shows evidence of being an effective independent learner by the following:

1. Reflects on own learning and determines learning requirements and strategies;
2. Sources and evaluates information;
3. Accesses, comprehends and applies knowledge acquired outside formal instruction;
4. Critically challenges assumptions and embraces new thinking.

Range Statement: Operate independently in complex, ill-defined contexts requiring personal responsibility and initiative, accurately self-evaluate and take responsibility for learning requirements; be aware of social and ethical implications of applying knowledge in particular contexts.

Exit level outcome 10: Engineering Professionalism

Learning outcome: Demonstrate *critical awareness* of the need to act professionally and ethically and to exercise judgment and take responsibility within own limits of competence.

Associated Assessment Criteria:

The candidate exhibits professionalism by the following:

1. Being aware of requirements to maintain continued competence and to keep abreast of up-to-date tools and techniques;
2. Displays understanding of the system of professional development.
3. Accepts responsibility for own actions;
4. Displays judgment in decision making during problem solving and design;
5. Limits decision making to area of current competence;
6. Reason about and make judgment on ethical aspects in case study context;
7. Discerns boundaries of competence in problem solving and design.

Range Statement: Evidence includes case studies typical of engineering practice situations in which the graduate is likely to participate.

14. Note on Associated Assessment Criteria

Overlap exists between performances specified for different outcomes. The same evidence may be used toward assessing competence under different outcomes.

15. International Comparability

International comparability of the whole qualification standard is ensured through the Washington Accord. The standards are comparable with those for professionally-oriented bachelors degrees in engineering in countries having comparable engineering education systems to South Africa: Australia, Canada, Hong Kong China, Ireland, New Zealand, United Kingdom, United States of America. Comparability is audited on a six-yearly cycle by a visiting Washington Accord team.

16. Integrated Assessment

Providers of programmes shall in the quality assurance process demonstrate that an effective *integrated assessment* strategy is used. Clearly identified components of assessment must address *summative assessment* of the exit level outcomes. Evidence should be derived from major work or multiple instances of limited scale work.

17. Recognition of Prior Learning

Providers may make use of recognition of prior learning at intermediate levels but must take full responsibility for assessing the exit level outcomes.

18. Articulation Possibilities

The exit level outcomes ensure that a graduate of a programme meeting these standards would meet requirements for entry to an number of programmes including:

1. A Learnership programme directed at becoming registered as a Professional Engineer or meeting other industry requirements;
2. Formal specialist study toward the Graduate Diploma in Engineering;
3. A postgraduate Bachelor of Laws (LlB) programme;
4. Specialist coursework masters programmes, for example MEng;
5. Research masters programmes leading to the MSc(Eng), with or without coursework components;
6. With appropriate work experience, the Master of Business Administration.

19. Moderation and Registration of Assessors

Providers of programmes shall in the quality assurance process demonstrate that an effective moderation process exists to ensure that the assessment system is consistent and fair.

Registration of assessors is delegated by the Higher Education Quality Committee to the Higher Education providers responsible for programmes.

References

1. Definition of Terms to Support the ECSA Standards and Procedures System, Document G-04, Available via www.ecsa.co.za.

Appendix A: Definition of Knowledge Areas

Basic Sciences: physics (including mechanics), chemistry, earth sciences and the biological sciences which focus on understanding the physical world, as applicable in each engineering disciplinary context.

Complementary studies: cover those disciplines outside of engineering sciences, basic sciences and mathematics which: (a) are essential to the practice of engineering, including engineering economics, the impact of technology on society and effective communication; and (b) broaden the student's perspective in the humanities or social sciences to support an understanding of the world.

Computing and Information Technologies: encompasses the use of computers, networking and software to support engineering activity and as an engineering activity in itself as appropriate to the discipline.

Engineering Design and Synthesis: is the creative, iterative and often open-ended process of conceiving and developing components, systems and processes. Design requires the integration of engineering, basic and mathematical sciences, working under constraints, taking into account economic, health and safety, social and environmental factors, codes of practice and applicable laws.

Engineering Sciences: have roots in the mathematical and physical sciences, and where applicable, in other basic sciences but extend knowledge and develop models and methods in order to lead to engineering applications and solve engineering problems.

Mathematical sciences: an umbrella term embracing the techniques of mathematics, numerical analysis, statistics and aspects of computer science cast in an appropriate mathematical formalism.

Appendix B: Method of Calculation of SAQA Credits and Allocation to Knowledge Area.

The method of calculation assumes that certain activities are scheduled on a regular weekly basis while others can only be quantified as a total activity over the duration of a course or module. This calculation makes the following assumptions:

1. Classroom or other scheduled contact activity generates notional hours of the student's own time for each hour of scheduled contact. The total is given by a multiplier applied to the contact time.
2. Two weeks of full time activity accounts for assessment in a semester.
3. Assigned work is generates only the notional hours judged to be necessary for completion of the work and is not multiplied.

Define for each course or module identified in the rules for the degree:

Type of Activity	Time Unit in Hours	Contact Time Multiplier
L = number of lectures per week	T_L = duration of a lecture period	M_L=total work per lecture period
T = number of tutorial per week	T_T = duration of a tutorial period	M_T=total work per tutorial period
P = total practical periods	T_P = duration of a practical period	M_P=total work per practical period
X = total other contact periods	T_X = duration of other period	M_X=total work per other period
A = total assignment non-contact hours	T_A = 1 hour	
W = number of weeks the course lasts (actual + 2 week per semester for examinations, if applicable to the course or module)		

The credit for the course is:

$$C = \{W(LT_L M_L + TT_T M_T) + PT_P M_P + XT_X M_X + AT_A \}/10$$

The resulting credit for a course or value may be divided between more than one knowledge area. In allocating the credit for a course to multiple knowledge areas, only new knowledge or skills in a particular area may be counted. Knowledge and skills developed in other courses and used in the course in question shall not be counted. Such knowledge is classified by the nature of the area in which it is applied. In summary, no knowledge is counted more than once as being new.

The calculation of credit for workplace training is for further study.

Appendix C: Consistency of Exit Level Outcomes with Critical Crossfield Outcomes

SAQA Critical Cross-Field Outcomes	Equivalent Exit Level Outcome
Identifying and solving problems in which responses display that responsible decisions using critical thinking have been made.	ELO 1, 2, 3, 5
Working effectively with others as a member of a team, group, organization and community.	ELO 8
Organising and managing oneself and one's activities responsibly and effectively	ELO 8
Collecting, analyzing, organizing and critically evaluating information.	ELO 1, 3, 5
Communicating effectively using visual, mathematical and/or language skills	ELO 2, 6
Using science and technology effectively and critically, showing responsibility toward the environment and health of others	ELO 2, 3, 4, 5, 7
Demonstrating an understanding of the world as a set of related systems by recognizing that problem contexts do not exist in isolation	ELO 1, 3,
Contributing to the full personal development of each learner and the social and economic development of society at large, by making it an underlying intention of the programme of learning to make an individual aware of:	
• reflecting on and exploring a variety of strategies to learn more effectively	ELO 9
• participating as responsible citizens in the life of local, national and global communities	ELO 10
• being culturally and aesthetically sensitive across a range of contexts	ELO 7
• exploring education and career opportunities	ELO 8
• Developing entrepreneurial opportunities	ELO 3

Revision History

Version	Date	Revision authorised by	Nature of revision
Revision - 0	16 April 1998	Council	Initial Issue
Rev-1/Draft-A	20 July 2000	UAC: Recommended to Council	Change to SAQA Credit (3.1) Editorial changes
Rev-1	11 Aug 2000	Council	Put into PDF format
Revision-2	26 July 2004	Council, approved by SAQA, registered on NQF	Clarified outcome, SAQA elements added