SUBJECT BENCHMARK STATEMENT

IN

MECHANICAL ENGINEERING

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FOREWORD

The work in connection with the development of Subject Benchmark Statements was begun in August 2003 as a part of the overall quality assurance framework that supports academic standards and the furtherance and dissemination of good practice in Universities in Sri Lanka.

Subject Benchmark Statements will support and promote quality and standards by:

- Providing universities with a common and explicit reference point for internal and external programme approval and review;
- Guiding and promoting curriculum development, especially in new departments and new universities, and in other institutions of higher education;
- Evolving over time to take account of changes and innovations that reflect subject development and new expectations;
- Providing an authoritative and widely recognized statement of expectations of what is expected of a graduate in a specific (or designated) subject area in a form readily accessible to students, employers and others with a stake in higher education;
- Providing a clear and transparent reference point for External Examiners;
- Assisting international comparison and competitiveness of higher education awards and student achievement.

SUBJECT BENCHMARK STATEMENT
MECHANICAL ENGINEERING

1. INTRODUCTION

1.1 Subject Bench Mark Statement (SBS)– Scope and Purpose

Benchmarking of academic standards is an essential component of quality assurance in the university system. Subject benchmark statements provide a means for the academic community to describe the nature and characteristics of programmes in a specific subject, subject aims, expected subject knowledge and understanding, expected skills and attitudes of award holder, teaching and learning strategies, assessment strategies, strategies used to maintain standards and minimum standards for the award of the degree in a subject area.
Subject benchmark statements are used for a variety of purposes.
Primarily they are important as they describe the nature characteristics of the subject area, the expected attributes and capabilities of award holders, and the minimum standards for the award of the degree, and provide:

- Academic staff and institutions with a framework for developing and specifying the intended learning outcomes of programmes;
- Institutions with a minimum standard for the award of a degree in a subject area;
- Peer reviewers with a point of reference, among others, for making judgments about the appropriateness of academic standards within institutions in pursuit of internal quality assurance;
- Professional and statutory bodies with academic and practitioner standards that should be expected of graduates.

Benchmarking academic standards may also provide information for:

- Students, employers and others about the range of provision in particular subject/discipline areas, the qualities developed in graduates, and the standards that would be expected of graduates in those areas;
- The public at large about the nature of higher education awards.

SBS also describes the nature and extent, in Mechanical Engineering.
This SBS for Mechanical Engineering has been undertaken as an activity of the Quality Assurance and Accreditation Council (QAAC) of UGC by subject specialists as an initial document for further consideration and adoption by relevant stakeholders in Mechanical Engineering. This Benchmark statement refers to the Bachelors Degree.
The statement is not a syllabus and is not intended to prescribe the time devoted to each component or the order in which the components are to be taught.

1.2 Level of Teaching

This SBS covers Bachelor of the Science of Engineering in Mechanical Engineering (Honours) Degree. Bachelors degree programme in engineering in Sri Lanka must be of a duration of not less than four (4) academic years of full-time equivalent study based on entry through a satisfactory level of achievement in relevant subjects

at the General Certificate of Education (Advanced Level) examination conducted by the Department of Examinations of Sri Lanka, or through an equivalent qualification.

1.3 Nature and Extent

Mechanical Engineering is concerned with developing, providing and maintaining relevant infrastructure, products, processes and services for society. Mechanical Engineering deals with the total life cycle of a product, process or service, from conception, through design and manufacture, to decommissioning and disposal, within the constraints imposed by the economic, commercial, legal, social, cultural and environmental considerations. Mechanical Engineering is the base for diverse industry applications for the realization of relevant infrastructure. This requires the mechanical engineers to possess knowledge and skills for applying the principles of science, mathematics and management for creating things that are new solutions. Such creativity and innovation is essential for developing economically viable and sustainable solutions for supporting many mechanical engineering applications in diverse industry sectors. Mechanical Engineering demands continuous professional development during and after graduate programme as well as skills for analytical work, research studies, problem solving and team work.

1.4 Scope of Employment of Graduates

Mechanical Engineering graduates should become employable in varied sub-sectors of Mechanical Engineering such as plant and energy engineering, manufacturing, automation and mechatronics, Bio Medical Engineering, and building services which demand creativity and innovativeness to employ their knowledge and skills.

2. SUBJECT AIMS

The main aims of a degree programme in Mechanical Engineering are,

- To provide knowledge and understanding of essential facts, concepts, theories and principles of mechanical engineering and its underpinning science and mathematics
- To develop intellectual ability to use quantitative tools of science and engineering to the analysis of problems at an appropriate level of detail for formulating and developing creative and innovative solutions and designs.
- To enable the students to develop an appreciation of the multidisciplinary engineering contexts and the considerations of social, economic, commercial, environmental, ethical concerns affecting their work.
- To impart practical engineering skills such as conducting work in laboratories, workshops and in industry, managing projects and the use of computer software in design and management.
- To develop transferable skills such as leadership, communication, teamwork, self learning and continuous professional development.

3. SUBJECT KNOWLEDGE AND UNDERSTANDING

The mechanical engineering degree programme should have a compulsory core from which specializations could develop. Such core should provide a coherent and integrated broad based knowledge with emphasis on principles of mechanical engineering and science with provision for a certain degree of specialty in a chosen stream for specialization. The criteria for curriculum content specified in the following sections ensure that the graduate receives a foundation in mathematics and basic sciences, a broad preparation in mechanical engineering sciences, engineering design and projects and an exposure to other non-technical subjects that complement the technical subjects. These components are judged both qualitatively and quantitatively. Deviations from the following subject content should be acceptable if it is satisfied that such deviations serve to promote innovation in mechanical engineering education and disseminate good practices.

The initial education of a professional engineer should provide an in-depth core of scientific and technical skills together with a sufficient breadth of experience in complementary studies, consisting of humanities, social sciences, arts, management, engineering economics and communication. It is appropriate for the programme structure to be designed in such a way to give a progressive shift of emphasis from engineering science and principles in the early stages to more integrated studies in the final year.
The programme should include, a broad based core covering the following areas together with specialized study in selected streams of mechanical engineering.

Engineering Analysis

- Understanding of mechanical engineering principles and the ability to apply appropriate mathematical methods, tools and techniques proficiently for the analysis and solution of engineering problems
- Ability to identify and describe the performance of systems and components by the use of analytical methods and modelling techniques
- Ability to develop a holistic view of an engineering problem

Design

This involves the creative and innovative ability to design and develop an economically viable product, process or system which meets a defined need. The programme should impart knowledge and skills to,

- Investigate, identify and define a problem and identify its constraints and broad environmental issues
- Understand customer and user needs including industrial design considerations
- Appreciate the importance of designing for functionality, quality, safety, production, maintenance and disposal
- Be creative and innovative in developing alternative solutions and evaluating them
- Make use of design codes of practice and standards
- Use computational tools and software
- Manage the design process

Exposure to professional Engineering practice

Industrial training in a practical engineering environment, directly assisting professional engineers, would give the student a valuable insight into professional practice. Such experience would complement the formal studies at the educational establishment, and should ideally consist of several different types of experience. This must include practical experience in the basic manufacturing and construction techniques applicable to the student's chosen discipline of engineering. The opportunity to observe human and industrial relations, job organization, maintenance, safety and environmental procedures from the point of view of the general workforce is an important component in the early preparation for a career as a professional engineer.

- Knowledge of characteristics of particular materials, equipment, processes and products.
- Workshop and laboratory skills.
- Awareness of nature of intellectual property and contractual issues.
- Understanding of appropriate codes of practice and industry standards.
- Understanding use of technical literature and other information sources.

In order to achieve the above objectives any degree programme in Mechanical Engineering should comprise the following areas, [Academic Credit (AC): 14 lecture hours or equivalent content through other means.]

(a) Mathematics, Statistics, Basic Sciences and Computing (Minimum of 25 ACs)

Mathematics should include appropriate elements of linear algebra, differential and integral calculus, differential equations, probability, statistics, numerical analysis and discrete mathematics. Some of the mathematical techniques may be taught within other subjects in the programme where they are relevant.

The basic sciences component of the curriculum must include elements of physics and chemistry, and other relevant elements of life sciences and earth sciences. These subjects are intended to impart an understanding of natural phenomena and relationships through the use of analytical and / or experimental techniques.

These subjects should be studied to a level necessary to underpin the engineering subjects of the programme and with a bias towards application in the teaching. The use of numerical methods of solution is encouraged, with an appreciation of the power and limitations of the computer for modelling engineering situations. Wherever practicable, it is preferred that mathematics, statistics and computing be taught in the context of their application to engineering problems, and it follows that some mathematical techniques may be learnt within other subjects in the programme. In addition to the use of computers as tools for calculation, analysis and data processing, courses should introduce their application in such areas as: Computer aided design and manufacture, Numerical methods, Programming techniques, Operational Research, Industrial economics and management and Mechatronics.

(b) Mechanical Engineering Sciences and Design (Minimum of 75 ACs)

Engineering science subjects would normally have their roots in basic sciences and mathematics, but carry knowledge further towards creative applications. They may involve the development of mathematical or numerical techniques, modelling, simulation and experimental procedures. Application to the identification and solution of practical engineering problems is stressed. In addition to engineering science subjects pertinent to the discipline, the curriculum must include engineering science content, which imparts an

appreciation of important elements of other engineering disciplines. A combination of engineering sciences, engineering design and projects and exposure to professional practice is recommended.
Engineering design integrates mathematics, basic sciences, engineering sciences and complementary studies in developing elements, systems and processes to meet specific needs. It is a creative and interactive process subject to constraints, which may be governed by standards or legislation.

The engineering curriculum must end with a significant design experience, which is based on the knowledge and skills acquired in earlier coursework. Such a project could give the student an exposure to the concepts of teamwork and project management. Whilst group projects, such as in design exercises, may be appropriate for work in earlier years, the final year project is required to demand individual analysis and judgment. Even though work may be carried out in small groups the student should be assessed independently from the work of others. The student is expected to develop techniques of literature review and information gathering.
The mechanical engineering sciences and design components of the curriculum must include appropriate content which requires the application of computers. The broad areas are,

- Manufacturing systems and industrial engineering
- Mechanics of machines and control systems
- Mechanics of solids
- Fluid mechanics
- Thermodynamics
- Machine elements and design
- Manufacturing Technology

Alongside the basic subjects, there must be a study of the principles and applications of,

- Energy and the Environment
- Electrical power and Machines
- Measurement and Instrumentation
- Electronics and Microprocessors
- Automobile Engineering
- Computer aided design

This category should also include engineering applications; materials, design, manufacture, construction. Emphasis on engineering applications in a degree programme aims to ensure that all engineering graduates have a sound understanding of up-to-date industrial practice, and in particular,

- To appreciate the characteristic behaviour of materials in a variety of user environments.
- To appreciate the range of manufacturing methods currently available and the skills which they require in people.
- To appreciate the cost aspects of material selection, manufacturing methods, operation and maintenance in their interaction with design and product marketing to understand the whole process of industrial decision-making in design, manufacture and use, and how it can be influenced not only by technical ideas but also by the practical constraints of financial and human resources and by the business and social environment of engineering.

Industrial training for a period of not less than twelve (12) weeks, and submission of a report on the training certified by the employer's representative to enable assessment and the award of credits. The ACs obtained for industrial training should not be less than 3 and not more than 6.

(c) Complementary Studies (Minimum of 30ACs)

A minimum of twenty (20) academic credits for studies in management, engineering economics and communication and ten (10) academic credits in humanities, social sciences, arts and professional ethics are recommended to complement the technical content of the curriculum.

While considerable flexibility is offered in the choice of suitable courses for the complementary studies component of the curriculum, some areas of study are considered to be essential in the education of an engineer. Accordingly, the curriculum must include studies on the impact of technology on society, engineering economics, and subject matter that deals with central issues, methodologies and thought processes of the humanities and social sciences.

Student's capability to effectively communicate, both orally and in writing, must also be developed. From the initial stages of the programme, careful attention must be paid to the development of clear and concise reporting skills of the students.

4. SKILLS AND ATTITUDES

4.1 Skills

4.1.1 General Skills

The graduates from a mechanical engineering programme of study must be adequately prepared to enter the profession and continue to practice having acquired the following generic skills:

- Academic skills and attitudes needed to comprehend and evaluate new information, concepts and evidence from various sources
- Ability to use appropriate knowledge and information to convert, utilize and manage resources optimally through effective analysis, interpretation and decision-making
- To be adaptive, creative, resourceful and responsive to changes in society, technology and career demands
- Ability to function effectively as an individual or as a member / leader of a team
- Ability to communicate effectively within the profession and with society at large
- Ability to plan self-learning and improve performance, as the foundation for lifelong learning/ CPD (continuing professional development)

4.1.2 Subject Specific Skills

They must possess practical mechanical engineering skills acquired through, for example, work carried out in laboratories and workshops, in industry through supervised work experience, in individual and group project work, and in the development and use of computer software in design, analysis, control and enterprise management.

4.2 Attitudes

- Respect for ethical standards and following professional codes of conduct
- An understanding of the need to undertake lifelong learning, and urge to developing the capacity to do so
- An appreciation of the role and responsibilities of the professional engineer in society and the impact that engineering makes on the environmental, economic, social and cultural aspirations of society.

5. TEACHING AND LEARNING STRATEGIES

The primary aim of teaching and learning strategies is to equip students with the necessary knowledge and skills appropriate to their profession. Learning process should establish an environment that fosters learning styles that create active deep learning opportunities and to develop problem-solving skills and higher order skills of reasoning and analysis in a structured and supportive environment. The teaching and learning strategies should be designed to progressively encourage the transition from a teacher-centred (dependent) learning to learner- centred (independent) learning so that students become increasingly responsible for their own learning as the programme advances.
A balanced selection of the following teaching and learning techniques can be used:

- Lectures
- Audio visual aids
- Laboratory classes
- Field classes/ excursions
- Project work
- Seminars
- Tutorials
- Workshops
- Discussions
- Problem-based learning
- Self-directed studies
- Research work
- Distance learning approaches
- Internet based resources
- Films and videos
- Guest lecturers from industry
- Text books/ Research papers
- Case studies
- Industry visits

In addition to the above and to supplement and consolidate their effect the following strategies are highly recommended:
Internal and external professional mentoring,
An industry-based (group) project, particularly in the final year,
In-plant training.

6. ASSESSMENT METHODS

Assessment methods are integral to teaching and learning but they are not the sole purpose of teaching and learning. They should be designed to match intended learning outcomes. They should aim to test subject knowledge and skills acquired. They provide a sort of information about the candidates that will be useful to employers.
A variety of assessment techniques may be employed to measure the knowledge, skills and attitudes (competence) of students within specified criteria. The methods may include,

- Closed-book examinations
- Open-book examinations
- Practical assessments
- Seminar presentations
- Project reports
- Laboratory reports
- Dissertations
- Essays
- Assignments
- Work experience reports
- Case studies
- Oral presentations
- Viva-voce examinations

The above list is not intended to be prescriptive or exhaustive. The assessment method must be chosen according to its appropriateness to the course. A combination of continuous assessment and end-of-course assessments should be preferred. Where possible students should be given feedback of their progress and attainment.

7. MAINTENANCE OF STANDARDS

Mechanical Engineering is a discipline which continues to expand steadily to embrace an ever-increasing range of knowledge and skills. Therefore it is important to monitor the achievement of knowledge, skills and attitudes described in this document as well as to continuously update the degree programme to meet the changing needs. Continuous monitoring could be achieved periodically through moderation by internal/ external examiners, reviews by external academics and professional bodies, accreditations by professional bodies and so on.
Such activities need to examine the availability of,

- A forward-looking, proactive educational culture and awareness of current developments in engineering education.
- Holistic approaches to curriculum design and delivery and to assessment.
- Staff that is active in role-modelling the generic attributes of a professional engineer.
- Active programmes in place to promote the objectives and also community consciousness, nationalization and internationalization.
- Appropriate processes for programme planning and curriculum development and review with the involvement of all relevant stakeholders.
- A rationale for introduction of new programmes, and evidence of demand and of adequate availability of resources.

- Clear evidence that the results of assessment of student performance and learning outcomes are being applied to the review and ongoing improvement of programme effectiveness.
- Effective processes for securing feedback from all programme constituents and applying it to the review and ongoing validation and improvement of programme objectives, curriculum, assessment and quality of learning and teaching.
- Effective advisory mechanisms for consulting and involving practicing professional engineers and leading employers of engineering graduates in forward planning and quality management.
- Programmes in place or under active development, for benchmarking programme standards against those of other universities, nationally and / or internationally.
- Graduate employment data and alumni and employer feedback and they give confidence in the programme, the Engineering Faculty/Department and the capability of its graduates.
- Effective records management system in the Faculty/ Department

8. LEVEL OF ACHIEVEMENTS

Threshold Level – This is the knowledge and skill level to be achieved by a graduate who obtains a second-class lower division or a general pass.

Good Level – This is the knowledge and skill level required to be achieved by a graduate who obtains a pass with a first class or in the second-class upper division.

At ***Threshold Level*** the graduate should demonstrate the basic ability at the minimum acceptable level and at the ***Good Level*** be proficient at an outstanding level in the following aspects of performance:

- Understand mechanical engineering principles and apply appropriate mathematical methods, tools and techniques for the analysis and solution of engineering problems
- Identify and describe the performance of systems and components by the use of analytical methods and modelling techniques
- Develop a holistic view of an engineering problem
- Investigate, identify and define a problem and identify its constraints and broad environmental issues
- Understand customer and user needs including industrial design considerations
- Appreciate the importance of designing for functionality, quality, safety, production, maintenance and disposal
- Be creative and innovative in developing alternative solutions and evaluating them
- Manage the design process
- Interpret characteristics of particular materials, equipment, processes and products.
- Understand nature of intellectual property and contractual issues.
- Understand appropriate codes of practice and industry standards.
- Use technical literature and other information sources.
- Undertake lifelong learning, and possess an urge to develop the capacity to do so
- Appreciate the role and responsibilities of the professional engineer in society and the impact that engineering makes on the environmental, economic, social and cultural aspirations of society.

- Understand the impact of technology on society, engineering economics, and subject matter that deals with central issues, methodologies and thought processes of the humanities and social sciences.
- Use quantitative tools of science and engineering to the analysis of problems at an appropriate level of detail for formulating and developing creative and innovative solutions and designs.
- Develop an appreciation of the multidisciplinary engineering contexts and the considerations of social, economic, commercial, environmental, ethical concerns affecting their work.
- Apply practical engineering skills such as conducting work in laboratories, workshops and in industry, managing projects and the use of computer software in design and management.
- Practise skills such as leadership, communication, teamwork, self learning and continuous professional development.
- Follow professional codes of conduct and respect ethical standards.
- Understand the impact of technology on society, engineering economics, and subject matter that deals with central issues, methodologies and thought processes of the humanities and social sciences.
- Use quantitative tools of science and engineering to the analysis of problems at an appropriate level of detail for formulating and developing creative and innovative solutions and designs.
- Develop an appreciation of the multidisciplinary engineering contexts and the considerations of social, economic, commercial, environmental, ethical concerns affecting their work.
- Apply practical engineering skills such as conducting work in laboratories, workshops and in industry, managing projects and the use of computer software in design and management.
- Practise skills such as leadership, communication, teamwork, self learning and continuous professional development.
- Follow professional codes of conduct and respect ethical standards.

References

1. Subject benchmark statement for the honours degrees in Engineering, QAA, UK.
2. Engineering Programme Accreditation Manual, 2006, The Institution of Engineers, Sri Lanka (IESL).

9. ANNEX1. MEMBERS OF THE BENCHMARK GROUP

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