Quality Assurance Council

2022

Subject Benchmark Statement

Physics

University Grants Commission – Sri Lanka

SUBJECT BENCHMARK STATEMENT IN PHYSICS

Foreword

A Subject Benchmark Statement (SBS) defines the nature of the study and the expected academic standards of a graduate in a specific subject area and it guides the expected level of the knowledge and the specific learning outcomes of a graduate in that subject area.

As a part of the overall Sri Lanka Qualification Framework (SLQF), the subject benchmark guides the academic standards and furtherance of a subject in a degree programme in higher education in Sri Lanka.

SBS 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 subjected to SLQF;
- guiding and promoting curriculum development, especially in new departments and new universities, and in other institutions of higher education;
- evolving to take account of changes and innovations that reflect subject development and new expectations;
- providing an authoritative and widely recognized statement of what is expected of a graduate in a specific subject area in a form readily accessible to students, employers, and others with a stake in higher education qualifications;
- providing a clear and transparent reference point for external examiners; and
- assisting international comparison and competitiveness of higher education awards and student achievement.

1 Introduction

1.1 About this SBS

This document was developed to update the previous SBS of Physics, which was adopted in 2006. SBS provides the general expectation of the academic standard of the subject of Physics and the expected broad learning outcome of degree programmes relevant to Physics. This guides the aims and objectives of a degree programme, the extent of the subject matter, and the expected skills of the graduates. Indeed, this benchmark statement provides provisions for variety and flexibility in degree programmes and encourages innovations within an agreed framework. It provides a point of reference for reviewers and an external source of reference when new programmes are designed and developed.

This SBS refers to three types of degree programmes, a three-year Bachelor of Science (B. Sc.) with Physics as one of the subjects, a four-year B. Sc. Honours with Physics as one of the two subjects and a four-year B. Sc. Honours in Physics.

1.2 Summary of the changes from the previous SBS

Previous SBS focused on two types of degree programmes, B. Sc. (General), and B. Sc. (Special). New SBS covers three types of degree programmes, B. Sc. (SLQF 5), B. Sc. Honours (SLQF 6) and B. Sc. Honours in Physics (SLQF 6). All sections are modified accordingly. In addition to the core and selected areas of Physics, additional areas are recommended covering the latest developments in research and industrial

applications. The employability of graduates in multidisciplinary areas is also considered.

1.3 Defining Principles

This SBS is prepared focusing the following principles for each degree programme.

1.3.1 B. Sc. with Physics as one of the subjects.

- This qualification is designed to prepare a graduate with a broad knowledge of theory, practice, and methodology of subjects they follow that enable them to work in a multidisciplinary academic and professional environment.
- Expect to know about the well-established principles and concepts in Physics.
- Graduates capable of undertaking necessary analysis to identify problems, find solutions to them, and able to disseminate the results effectively to specialists and wider society.
- Ability to display knowledge and skills necessary for employment or further studies.

1.3.2 B. Sc. Honours with Physics as one of the two subjects

- This qualification is designed to prepare a graduate with a broad knowledge of theory, practice, and methodology of two subjects they follow that enable them to work in a multidisciplinary academic environment or to achieve appropriate professional status as leaders in industry/commercial organizations
- Expect to know about the well-established principles and concepts in Physics and the other relevant subject with innovative skills for design and development.
- Graduates capable of undertaking necessary actions to solve problems in multidisciplinary areas with experts in different fields and to disseminate the results effectively to specialists and wider society.
- Ability to display knowledge and skills necessary for employment as managers or for further studies.

1.3.3 B. Sc. Honours in Physics

- An honours degree programme in Physics is designed to produce graduates with sound theoretical knowledge on the subject matter, applications, and methodology that enable them to obtain any appropriate professional status as senior leaders in industry/commercial organizations or prepare them for research-based careers.
- Expect a high level of intellectual independence to carry out further training and learning in the subject.
- Graduates capable of solving problems using concepts and analysis techniques.
- Ability to communicate Physics concepts and solutions to relevant practical problems to specialists and non-specialists.

2 Degree programmes covered by this Statement

This is the SBS for Physics. This statement defines the academic skills and standards that could be demonstrated by a graduate after successful completion of his/her respective degree programme, in terms of what he/she might know, do and understand, and describes the nature of the subject.

This statement also covers the three categories of degree programmes offered at SLQF Levels 5 or 6. The minimum credit requirement for the subject of Physics taught for Level 5 Bachelor's degree programme should be 24 credits. For Level 6 B. Sc. Honours degree programme with Physics as one of the two subjects shall be 45 credits, and B. Sc. Honours in Physics shall be 72 credits.

Any degree fulfilling the minimum requirement of 24 credits in core/selected areas, covering a minimum of 75% from core areas of Physics, can claim the student has followed Physics as a subject.

3 Aims and objectives of the Subject

The aim of teaching Physics at the undergraduate level is to provide students with a broad understanding of how the physical world works and the principles behind many important mechanisms, and helps them to develop quantitative reasoning skills required to think critically and creatively, and to provide necessary training to plan a wide range of careers in Physics.

The aims are achieved by offering Physics curriculum under 3 different focus areas at undergraduate levels, namely, three-year B. Sc. degree with Physics as a subject, four-year honours degree with Physics as one of the two subjects with industry orientation, and a four-year honours degree in Physics with in-depth knowledge in Physics to prepare them for research-based careers or to be leading professionals in the industry/commercial organizations.

All students are trained in experimental, mathematical, and computational skills that are considered as important skills to help them in future employment. Depending on the nature of the degree programme, courses offered by each university could vary in the depth and extent of Physics content, but still, cover the essential and fundamental areas of Physics.

The three-year B. Sc. degrees with Physics as a subject includes topics that cover core areas of Physics during the 1st and 2nd years moving into more applications in the 3rd year. The four-year honours degrees catering to two broad focus areas where there is a difference in advanced Physics content offered in the last two years. Degrees with more academic orientation offer the majority of Physics courses with the introduction of mathematical methods for the formulation of Physics theories, and industry-oriented degrees offer Physics courses with more industrial applications, such as automated systems, control systems, and new materials in the third and fourth years.

4 Nature and the extent of the Subject

Physics is a subject that covers a wide range of phenomena, from the smallest sub-atomic particles to the largest clusters of galaxies in the universe spanning many billions of light years. Because of the enormity of the depth and the breadth of the subject, selected core areas of Physics and selected relevant areas of applied topics are included in all B. Sc. and B. Sc. Honours degree programmes.

For B. Sc. or B. Sc. Honours degrees, one takes Physics as one of the subjects, and for a B. Sc. Honours in Physics degree programme Physics is taken as the major subject.

In B. Sc. degree programmes, broad knowledge of the core areas and some selected applied topics are included. The emphasis is given developing a basic understanding of physical concepts and their applications. Training in core areas together with selected topics provides the knowledge and skills necessary to apply Physics principles in practical and industrial applications. Laboratory work provides the necessary training related to the planning and execution of experiments, instrumentation, data acquisition, data processing and interpretation, report writing, and presentation. In addition, laboratory work provides the training necessary to present results with appropriate accuracy, error analysis, and proper units.

Basic training in Physics will prepare the graduates to work in many areas of Physics, in related areas of science and engineering, in education, industry or in commercial organizations.

B. Sc. honours degree programmes in Physics are designed so that the core subject areas can be covered at a greater depth. Honours degree programmes provide an additional selection of topics to strengthen the advanced subject areas. Sound knowledge of mathematics is an essential requirement for a Physics honours degree programme. For the experimental part of the programme, electronics is an important component in developing technical skills.

In honours degree programmes it is required to carry out an independent research project. Alternatively, students may carry out a design/development project aimed at investigating an industrial problem; develop a new process or a new measurement technique within an industrial or a commercial organisation. Both these activities (Research Project, and Design/Development Project) provide the student with the skills necessary to plan and carry out a detailed investigation (when necessary, as a member of a wider team), perform experiments, collect data, analyse, interpret, draw conclusions, write reports, and make presentations.

Honours degree programmes in Physics will prepare the graduates to work and develop a career in advanced research in many areas of Physics, in related areas of science and engineering, in education, in industry or in commercial organizations.
The following are chosen as the core areas of Physics, in which the students should have a sufficient level of understanding.

- Atomic, Nuclear and Particle Physics
- Classical Mechanics

- Condensed Matter Physics
- Electromagnetism
- Optics
- Quantum Mechanics
- Special Relativity
- Statistical and Thermal Physics
- Waves and Vibrations

In addition to the above core areas, courses from the following areas can be chosen as selected topics.

- Astronomy and Cosmology
- Astrophysics
- Biophysics
- Computational Physics
- Electronics
- Laser Physics
- Environmental Physics
- Geophysics
- Industrial Physics
- Introduction to General Relativity
- Mathematical Physics
- Medical Physics
- Meteorology
- Metrology
- Renewable Energy

Many graduates may eventually be working in industrial and commercial environments. As such, they will benefit from having well-developed presentation and communication skills, to communicate effectively with decision makers within these organizations. Many of these may not be familiar with detailed Physics / mathematics / scientific principles. Yet they will be responsible for implementing a necessary process or procedural changes based on the conclusions of scientific investigations. In addition, those who join industrial and commercial organisations will benefit from developing an awareness of various key areas affecting the commercial and industrial world, as well as an awareness of the impact of different cultures on communications and behaviour among industrial communities.

For this purpose, in addition to the areas in Physics, the following areas are recommended in their course of study.

- Artificial Intelligence
- Career Development
- Control Systems
- Data Science
- Economics
- Entrepreneurship
- Impact of Culture on Communications and Behaviour

- Management and Leadership
- Marketing
- Programming Languages
- Robotics
- Scientific Communication
- Statistical Quality Control
- Virtual Reality

5 Subject-specific learning outcomes in core areas

5.1 B. Sc. with Physics as one of the subjects

Students who offer Physics as one of the subjects in B. Sc. Degree programme should be able to:

Knowledge-

- comprehend the basic physical laws, principles and concepts, and awareness in how they are applied in science in our day-to-day life;
- develop competency in acquiring new knowledge and applying it in a variety of situations, make connection/links between concepts covered in different courses in Physics, recognize the interdisciplinary nature of contemporary Physics (e.g. Biophysics, Computational Physics, Medical Physics, etc.);
- handle the basic laboratory equipment and understand the standard methods of conducting Physics experiments; and
- use basic laboratory data analysis techniques, including error and statistical analysis, and develop skills in interpreting data graphically and reporting.

Skills-

- develop the ability to express their thinking in both oral and written form clearly, and efficiently acquire new information from many sources;
- communicate the concepts, principles and the results of their laboratory experiments using effective scientific writing and oral communication skills, participate effectively and productively in group work and discussions;
- demonstrate their ability to interact constructively as part of a team, whilst having the ability to work independently;
- develop the ability to manage the workload effectively and ensure to achieve the assigned task and other work on time;
- learn to pay attention to detail and to demonstrate their ability to handle precise and complex ideas, to construct logical arguments and to use technical language correctly;
- solve problems competently by identifying the key issues of a problem and formulating a strategy, apply appropriate techniques to arrive at a solution, test the correctness of the solution, and interpret the results;
- develop the confidence and creativity to try different approaches to make progress on challenging problems, gain experience in tackling open-ended problems that may cross subject boundaries; and
- develop their computing and ICT skills in a variety of ways, including their ability to use appropriate software and packages.

Attitudes-

- develop and demonstrate work ethic, which includes integrity, sense of responsibility, emphasis on quality and teamwork skill;
- develop the capacity to acquire new knowledge in Physics and their impacts, and continuously update and develop skills willingly to meet future challenges;
- manage their learning and to make use of appropriate texts, research-based materials or other learning resources;
- develop the ability to prioritize and schedule the workload and time while maintaining a harmonious and balanced lifestyle; and
- empower to learn and achieve, to acquire high-quality learning skills and habits which equip them dispositions for lifelong learning and to shape the world around them.

5.2 B. Sc. Honours with Physics as one of the two subjects

Students who offer Physics as one of the two subjects in B. Sc. Honours Degree programme should demonstrate the knowledge, skills and attitudes mentioned in Section 5.1 and be able to:

- acquire knowledge and understanding of most of the fundamental Physics laws and principles, and competence in the application of these principles to diverse areas of Physics;
- solve advanced problems in Physics using appropriate mathematical tools, identify the relevant Physics principles, translate problems into mathematical statements and apply their knowledge to obtain more precise solutions as appropriate;
- acquire laboratory skills, enabling them to take measurements in a Physics laboratory and analyse the measurements to draw valid conclusions;
- interpret measurements, considering the limitations of the measurements and the limitations of models; and
- develop the skills needed for oral and written scientific communication and will prove that they can think critically and work independently.

5.3 B. Sc. Honours in Physics

Students who offer Physics as the major subject in B. Sc. Honours Degree programme should demonstrate the knowledge, skills and attitudes mentioned in Sections 5.1, 5.2 and be able to:

- plan and execute a Research Project/investigation, execute and analyse critically the results of an experiment/investigation and draw valid conclusions, assess the link between theoretical results and experimental observation critically, communicate complex scientific ideas;
- master new techniques in a theoretical, computational or experimental context;
- gain experience of using textbooks, and other available literature, of searching databases and the internet, and of interacting with colleagues to derive important information, develop their skills in an independent investigation;
- develop the capacity to identify goals for future professional success and gain knowledge and develop skills, based on self-study and self-improvement;

- develop the skills to assess what equipment/instrumentation is appropriate for carrying out measurements, and to construct experimental apparatus or design experimental systems using available instrumentation and equipment; and
- use the new knowledge and skills acquired in constructive community service or engagement that recognizes the potential impact on local and global issues, including environmental impact and sustainability.

6 Teaching, Learning and Assessment process

6.1 Teaching and Learning

Physics is a hierarchical discipline that lends itself to the systematic exposition and the ordered and structured acquisition of knowledge. It is also an empirical subject. Practical skills, including an appreciation of the link between theory and experiment, should be developed. This leads to teaching-learning methods that may typically include:

- in-person and virtual lectures;
- blended teaching;
- tutorial discussions;
- group laboratory work;
- use of textbooks and other self-study materials;
- study visits;
- literature search;
- industrial training (4-6 Months);
- group project; and
- project work.

6.2 Learning

Approaches to skills development should encompass both transferable and subject-specific skills. It may well be most appropriate to develop both within the Physics context. Development between levels of study should be evident; for example, laboratory work may become open-ended with more demanding reporting criteria at higher levels. Computer skills should normally include the basics of programming, but it is increasingly the case that the use of programmes for simulation, computer algebra, and data analysis is most appropriate for the physicist. Skills may also be developed in the use of computers for the control of experiments and the acquisition of data.

6.3 Assessment

Each Physics course unit shall be evaluated by means of in-course assessment and an end of course examination. A variety of assessment methods are appropriate within a Physics programme, some of which are more suitable for formative assessment. Evidence of the standards achieved could be obtained from many of the following:

- written examinations;
- closed-book and open-book examinations;
- problem sheet/tutorial assignments;
- laboratory reports;
- practical examinations;
- individual project reports;

- team/group project reports;
- oral/seminar presentation;
- poster presentations;
- viva-voce interview;
- midterm assessment; and
- quizzes.

Assessments should be graded to assess a student's understanding of concepts, and the ability to develop mathematical models, to complete calculations, to solve new problems, and to communicate physical arguments. Time-constrained work has its place in testing the student's capacity to organize work as well as to think and to communicate under pressure. Such assessments should be augmented by others, such as presentations and project reports, which allow students to demonstrate what they can achieve with less severe time constraints. Skills such as project are planning and execution, research skills, application of IT, and report writing, are best assessed in this way. It is recommended to consider giving an only pass/fail grade for Industrial training.

7 Performance Standards

All students completing a degree programme in Physics should demonstrate the knowledge, ability, and skills mentioned in this statement. However, there may be different levels of attainment between different degree programmes. The minimum credit requirement for the B. Sc. degree should be 90 credits including 24 credits from Physics during the entire three academic year period. For the B. Sc. Honours and B. Sc. Honours in Physics the minimum credit requirement should be 120 credits including 45 and 72 credits, respectively, from Physics during the entire four academic year period. It is the responsibility of the institution to ensure that their regulations and procedures of assessments guarantee the standards of their awards. However, they must maintain above minimum requirements.

The minimum acceptable levels for threshold attainment and excellent attainment are proposed in Section 7.1 and Section 7.2, respectively.

7.1 Threshold Attainment

B. Sc.	**B. Sc. Honours**	**B. Sc. Honours in Physics**
The basic knowledge of understanding of concepts in Physics and the ability to use them in problem-solving and other applications	The basic knowledge and understanding of concepts in Physics. Awareness of their applications in industry and commerce, with the ability to apply them in routine industrial and commercial applications	The basic knowledge on the more fundamental principles in Physics, the ability to use them in problem-solving and to apply them in various branches in Physics
The ability to apply broadly defined Physics concepts in solving problems in industry	The ability to apply broadly defined Physics concepts in solving problems in the industry	The ability to solve advanced problems of Physics using mathematical tools
The ability to conduct experiments, analyse the	The ability to design, plan and execute experiments to	The ability to apply fundamental Physics knowledge in solving

results, and arrive at conclusions	investigate industrial problems, analyse data, draw valid conclusions	problems in industry
The ability in numerical manipulation and to present and interpret information graphically	The ability to design and develop experimental tools in the industry and use them to investigate, analyse results to draw valid conclusions	The ability to design, plan and execute an experiment or investigate, analyse results to draw valid conclusions, and compare the results with available information
The knowledge of the safe and proper handling of laboratory equipment	The knowledge of the safe and proper handling of laboratory equipment and their industrial applications	A good knowledge of the safe and proper handling of laboratory equipment for applications and research
The awareness and knowledge of design and make principles required to manufacture or modify parts required for experimental rigs.	The awareness and knowledge of design and make principles required to manufacture or modify parts required for experimental rigs	The awareness and knowledge of design and make principles required to manufacture or modify parts required for experimental rigs
The knowledge in the use of software packages for the analysis of data and retrieval of information	The knowledge in the use of software packages for the analysis of data and retrieval of information, simulation, data acquisition, and (where possible) operation of equipment in the industry Working knowledge of experimental techniques for current research in the industry	The knowledge in the use of software packages for the analysis of data and retrieval of information, simulation, data acquisition, (where possible) operation of equipment in the industry and modelling physical systems Working knowledge of experimental and mathematical techniques for current research in Physics
The ability to write scientific reports and communicate scientific information	The ability to write scientific reports and communicate scientific information	The ability to write scientific reports, research papers and communicate scientific information
Self-learning capability and commitment to update their knowledge of Physics on a continual basis	Self-learning capability to update their knowledge of Physics and ability to learn and work with new processes and procedures	Self-learning capability to update their knowledge of Physics and ability to learn and work with new processes and procedures

7.2 Excellence Attainment

B. Sc.	B. Sc. Honours	B. Sc. Honours in Physics
The sound knowledge of understanding concepts in Physics, ability to use them in applications and problem solving, and competence in applications in diverse areas in Physics	The sound knowledge and understanding of concepts in Physics. Awareness of their applications in industry and commerce, with ability to apply them in routine industrial and commercial applications The ability to apply Physics concepts, and where necessary develop models, in solving complex problems in the industry	In-depth knowledge of more fundamental principles in Physics, ability to use them in problem-solving and to apply in various branches in Physics and other disciplines The ability to apply fundamental Physics knowledge and where necessary develop models, in solving complex problems in research and development
The ability to conduct experiments, analyse the results critically, produce valid conclusions, compare with available results, and make predictions	The ability to design, plan and execute experiments to investigate complex industrial problems involving many disciplines, analyse results critically, draw valid conclusions The ability to propose modifications to a model, so that the model predictions and experimental behaviour of the system under investigation are aligned	The ability to design, plan and execute a complex Physics Experiment (Research Project) or an investigation to solve a complex industrial problem involving many disciplines, analyse results critically, draw valid conclusions, develop models to make theoretical predictions The ability to propose modifications to a model, so that the model predictions and experimental behaviour of the system under investigation are aligned
A good knowledge of the safe and proper handling of laboratory equipment	A good knowledge of the safe and proper handling of laboratory equipment and their industrial applications The ability to select suitable equipment to solve problems related to the industry	A very good knowledge of the safe and proper handling of laboratory equipment The ability to select the suitable equipment for solving a given problem and to develop or modify experimental tools when and where necessary to perform experiments
The ability to design and make, or modify, parts for experimental rigs	The ability to design and make, or modify, parts for experimental rigs	The ability to design and make, or modify, parts for experimental rigs
The ability to construct possible arguments to support explanations	The ability to construct possible arguments to support explanations in defending the conclusions of a research project concisely, accurately, and informatively	The ability to construct possible arguments to support explanations in defending the conclusions of a research project concisely, accurately, and informatively
Competence in the use of software packages for	Competence in the use of software packages for the	Competence in the use of software packages for the analysis of data,

the analysis of data and retrieval of information	analysis of data and retrieval of information, simulation, data acquisition, and (where possible) operation of equipment in the industry	retrieval of information, simulation, data acquisition, (where possible) operation of equipment in the industry and modelling physical systems
The ability in numerical manipulation and to present and interpret information graphically	A sound knowledge of experimental techniques applicable to the industry	A sound knowledge of experimental and mathematical techniques for current research in Physics
The ability to write scientific reports and communicate scientific information	The ability to write scientific reports and communicate scientific information to industrial and non-scientific audiences	Excellent ability to write scientific reports, research papers and communicate scientific information to scientific and non-scientific audiences
Demonstrated self-learning capability and commitment to update their knowledge of Physics on a continual basis	Demonstrated self-learning capability to update their knowledge of Physics and demonstrated commitment to learn and work with new processes and procedures	Demonstrated self-learning capability to update their knowledge of Physics and demonstrated commitment to learn and work with new processes and procedures

Annexures

A. Members of the Committee

- Senior Professor W G D Dharmaratna (Chairman)-University of Ruhuna
- Senior Professor D U J Sonnadara, University of Colombo
- Senior Professor S R D Kalingamudali, University of Kelaniya
- Senior Professor P Ravirajan, University of Jaffna
- Senior Professor J C N Rajendra, The Open University of Sri Lanka
- Senior Professor L B D R P Wijesundera, University of Kelaniya
- Professor A R Kumarasinghe, University of Sri Jayewardenepura
- Professor L R A K Bandara, University of Peradeniya
- Professor V P S Perera, The Open University of Sri Lanka
- Professor I M K Fernando, University of Colombo
- Professor P Samarasekera, University of Peradeniya
- Professor (Mrs) C P Abayaratne, University of Sri Jayewardenepura
- Professor G M L P Aponsu, Sabaragamuwa University of Sri Lanka
- Professor N G S S Gamage, University of Sri Jayewardenepura
- Dr W A S Wijesinghe, Wayamba University of Sri Lanka
- Dr K Devendra, Industry expert from UK (Former Chief of Sub-Systems Rolls Royce plc, and Former Head of Value Stream-Assystem, UK)
- Dr (Ms) H O Wijewardane (Secretary)-Rajarata University of Sri Lanka

B. Other relevant material

- Previous Subject Benchmark Statement- Aug 2006- Published by UGC
- UGC Report of the Workshop on Education in Science: Present Status and Future Directions, Organized by the Standing Committee on Sciences of the University Grant Commission- 2005