Subject Benchmark Statement

Physics, Astronomy and Astrophysics

Version for Consultation

October 2024

Contents

About this Statement

This QAA Subject Benchmark Statement for Physics, Astronomy and Astrophysics (often shortened to Physics within this Statement) defines what can be expected of graduates in terms of what they might know, do and understand at the end of their studies. Subject Benchmark Statements are an established part of the quality assurance arrangements in UK higher education, but not a regulatory requirement. They are sector-owned reference points, developed and written by academics. Subject Benchmark Statements also describe the nature and characteristics of awards in a particular discipline or area. Subject Benchmark Statements are published in QAA's capacity as an expert quality body on behalf of the higher education sector. A summary of the Statement is also available on the QAA website.

Key changes from the previous Subject Benchmark Statement include:

- a revised structure for the Statement, which includes the introduction of cross-cutting themes of:
    - equity, diversity and inclusion
    - accessibility and the needs of disabled students
    - education for sustainable development
    - employability, entrepreneurship and enterprise education
    - generative artificial intelligence
- a comprehensive review updating the context and purposes, including course design and content, in order to inform and underpin the revised benchmark standards.

How can I use this document?

Subject Benchmark Statements are not intended to prescribe any particular approaches to teaching, learning or assessment. Rather, they provide a framework, agreed by the subject community, that forms the basis on which those responsible for curriculum design, approval and updating can reflect upon a course, and its component modules. This allows for flexibility and innovation in course design while providing a broadly accepted external reference point for that discipline.

They may also be used as a reference point by external examiners when considering whether the design of a course and the threshold standards of achievement are comparable with those of other higher education providers. Furthermore, Statements can support professional, statutory and regulatory bodies (PSRBs) with their definitions and interpretations of academic standards.

You may want to read this document if you are:

- involved in the design, delivery and review of courses in Physics, Astronomy or Astrophysics
- a prospective student thinking about undertaking a course in Physics, Astronomy or Astrophysics
- an employer, to find out about the knowledge and skills generally expected of Physics, Astronomy or Astrophysics graduates.

Relationship to legislation

The responsibility for academic standards lies with the higher education provider which awards the degree. Higher education providers are responsible for meeting the requirements of legislation and any other regulatory requirements placed upon them by their relevant funding and regulatory bodies. This Statement does not interpret legislation, nor does it incorporate statutory or regulatory requirements.

The status of the Statement will differ depending on the educational jurisdictions of the UK. In England, Subject Benchmark Statements are not sector-recognised standards as set out under the Office for Students' regulatory framework. However, they are specified as a key reference point, as appropriate, for academic standards in Wales under the Quality Assessment Framework for Wales and in Scotland as part of the Quality Enhancement Framework. Subject Benchmark Statements are part of the current quality arrangements in Northern Ireland. Because the Statement describes outcomes and attributes expected at the threshold standard of achievement in a UK-wide context, many higher education providers will use them as an enhancement tool for course design and approval, and for subsequent monitoring and review, in addition to helping demonstrate the security of academic standards.

Additional sector reference points

Higher education providers are likely to consider other reference points in addition to this Statement when designing, delivering and reviewing courses. These may include requirements set out by PSRBs and industry or employer expectations. QAA has also published Advice and Guidance to support the Quality Code, which will be helpful when using this Statement – for example, in course design, learning and teaching, external expertise and monitoring and evaluation.

Explanations of unfamiliar terms used in this Subject Benchmark Statement can be found in QAA's Glossary. Sources of information about other requirements and examples of guidance and good practice are signposted within the Statement where appropriate.

1 Context and purposes of a Physics, Astronomy or Astrophysics degree

What is Physics?

1.1 Physics is concerned with the observation, understanding and prediction of natural phenomena and the behaviour of fabricated systems. Astronomy and Astrophysics courses generally include a core of Physics as well as (but need not be limited to) the application of physical principles to astrophysical systems. In this Statement we will therefore use 'Physics' to refer to all of Physics, Astronomy and Astrophysics.

1.2 Physics deals with profound questions about the nature of the universe and with some of the most important practical, environmental and technological issues of our time – examples are energy, climate and sustainability. Its scope is broad and involves mathematics and theory, experiments and observations, computing and technology.

1.3 Physics provides ideas and techniques which drive developments in related disciplines, including chemistry, computing, engineering, materials science, mathematics, medicine, biophysics and the life sciences, earth sciences, meteorology, environmental science, statistics, and archaeology and the preservation of cultural artefacts.

1.4 Physics is characterised by the idea that systems can be understood by identifying a few key quantities, such as energy and momentum, and the universal principles that govern them. Part of the appeal of the subject is that there are relatively few such principles and that these apply throughout science and not just in Physics. The laws of mechanics are a good example; first deduced from observations of planetary motion, they govern systems familiar from everyday life as well as many of the phenomena observed in the movement of stars and galaxies.

1.5 To make quantitative predictions, Physics uses theoretical models usually expressed in mathematical terms and often involving approximations. The types of approximation used to find satisfactory models of experimental observations turn out to be very similar whether the underlying laws are those of classical physics, statistical mechanics or quantum theory. Typically, an idealised model of some phenomenon is established, the equations for the model are solved and the results related back to what is observed experimentally. Sometimes a model turns out to be appropriate in very different circumstances to that for which it was originally devised. For example, the degenerate Fermi gas model describes the behaviour of electrons in both a metal and a white dwarf star.

1.6 Computational approaches are also central to Physics. They have become essential in modelling systems from the subatomic, through materials, to the cosmological scale and in the analysis of large data sets. Increasingly, Physics develops deep-learning algorithms and artificial intelligence (AI) to understand and simulate physical systems.

1.7 Physics is an empirical science. The skills and methods used to make measurements are an integral part of Physics and the final test of the validity of any self-consistent theory is whether it agrees with experiment. Many important discoveries are made as the result of the development of new experimental techniques or instrumentation. For example, the techniques developed to liquefy helium subsequently led to the totally unexpected discovery of superconductivity, superfluidity and the whole field of low temperature Physics. Instruments developed originally in Physics can find applications in other branches of science and elsewhere. For example, the synchrotron radiation emitted by electrons in accelerators, which were originally designed to study elementary particles, is now used to study the properties of materials in engineering, biology and medicine.

1.8 Progress in Physics requires imagination and creativity. It is often the result of collaboration between physicists from a diverse range of backgrounds (both culturally, and in the sense of sub-fields of Physics as well as experimentalists, computational physicists or theorists) and can involve the exchange of ideas and techniques from outside Physics. Examples include chemistry, computing, engineering, the life sciences and mathematics.

1.9 Studying Physics brings benefits that last a lifetime. These include:

- a practical approach to problem-solving
- often using mathematical formulation and solution
- the ability to reason clearly and communicate complex ideas
- familiarity with information and communication technologies
- ability to judge statistical presentation of results
- acquisition of self-study, collaborative and teamwork skills
- the pleasure and satisfaction that comes from being able to understand the latest discoveries in science.

1.10 Physics graduates find employment across a wide range of established and developing fields, including engineering, technology and medicine, along with finance, information technology (IT), education and management.

Purposes and characteristics of a Physics, Astronomy or Astrophysics degree

1.11 A Physics degree develops a deep understanding of the underlying principles of Physics and how they explain phenomena observed in the physical world from the subatomic scale to the largest scale of the universe. Building the capacity to describe the physical world provides a vehicle for the student to acquire problem-solving skills, a knowledge of applicable mathematics, an appreciation of experimental techniques and data analysis, an ability in coding, and communication and teamwork skills. This combination of skills makes Physics graduates highly employable in roles which directly involve Physics and a multitude which do not.

1.12 Degrees in Physics include the more general and fundamental topics of Physics alongside a selection of more advanced topics. Courses vary in the emphasis given to different areas of Physics. For example, theoretical physics courses generally include more mathematical and computational skills, usually replacing much or possibly all conventional laboratory work.

1.13 Applied physics courses often have a technological focus. Some degree courses offer placements in schools, higher education provider research groups or industry. Joint and dual honours courses vary in the amount and extent of Physics content, depending on the precise definition and title of the course in question, but still cover the fundamental topics of Physics. In addition to this, integrated master's degree courses provide a greater depth of knowledge that is frequently informed by current research, further development of subject-specific skills and enhanced project work.

1.14 Physics courses cater for students planning to move on to research and development (in industry or academia), as well as for students looking for a broad-based Physics education which will make them numerate, articulate and employable (see the section on Employment, enterprise and entrepreneurship).

1.15 The fundamental areas of Physics - which all Physics degrees will cover to some extent - include classical mechanics, relativity, quantum physics, electromagnetism, thermodynamics and statistical physics, the physics of light and waves, and the properties of matter. All Physics degrees will provide students with an appreciation of underlying principles which cross the fundamental areas – for example, principles of equilibrium and conservation laws.

1.16 As part of a Physics degree, students also study the application of fundamental principles to particular areas. These may include (but need not be limited to) astrophysics, atomic physics, environmental physics, fluids, hard and soft condensed matter, materials, medical physics, nuclear and particle physics, advanced or applied optics and plasmas, as well as the application of physics to other disciplines.

1.17 Astronomy and Astrophysics degrees typically extend this core to cover topics generally including (but not limited to) cosmology: the structure, formation and evolution of stars and galaxies, planetary systems, and high-energy phenomena in the universe.

1.18 Physics degrees provide students with an appreciation of recent developments in Physics and will cover some of the fundamental areas to sufficiently advanced level to enable students to engage with current scientific research literature.

1.19 All Physics degrees cover to some extent:

- mathematics, an essential part of Physics, where students gain sufficient mathematical skills to enable modelling of the physical world
- computing, including code development and use of software packages; in some Physics courses students will cover additional topics, for example, computational and numerical methods, control of experiments and the acquisition of data
- problem solving, both practical and theoretical
- estimation and approximation, including an understanding of inherent uncertainty and appreciation of limitations
- an appreciation of how to plan and execute experiments or simulations
- project management and the ability to perform open-ended investigations
- data analysis and visualisation.

1.20 Physics graduates develop professional skills, including:

- the ability to approach new problems flexibly and adaptably
- clear communication of complex data and ideas using media appropriate to the information being conveyed and the audience receiving it
- the ability to work both individually and in teams
- time and deadline management
- critical analysis of their own and others work
- the ability to identify the potential ethical issues in their work
- an appreciation that to fabricate, falsify or misrepresent data or to commit plagiarism constitutes unethical scientific behaviour. A professional physicist should be objective, unbiased and truthful in all aspects of their work and recognises the limitations of their experimental techniques and calculations and, more fundamentally, their knowledge
- an understanding of what constitutes a safe working environment
- an appreciation of environmental and sustainability issues

- knowledge of professional practice. Some examples may include business awareness, project management, entrepreneurship and intellectual property.

1.21 The threshold standards in paragraphs 4.3-4.6 in section 4 provide some further detail of subject knowledge, understanding and generic skills.

Equity, diversity and inclusion

1.22 Physics is fundamental to understanding the world around us and should be open to all through inclusive teaching covering the wide range of experiences, cultures and backgrounds of students. Physics can only be truly open to all when the defining equity, diversity and inclusion (EDI) principles of the Equality Act (covering England, Scotland and Wales) and related legislation that applies to Northern Ireland, are embedded in Physics culture, curricula, teaching and assessment methods. Protected characteristics (including age; gender reassignment; being married or in a civil partnership; being pregnant or on maternity leave; disability; race including colour, nationality, ethnic or national origin; religion or belief; sex and sexual orientation) and personal circumstances (such as caring responsibilities or regional or more general economic disadvantage) can all affect the way in which individuals experience the world and the way they are perceived by others. In Physics, the contribution of every individual should be welcomed, enabled and encouraged.

1.23 The Physics curriculum encompasses subject content, delivery, engagement, assessment methods, and the professional practices that students prepare for. It should reflect the diversity of people, ideas and applications that contribute, and have contributed, to the development of the discipline and make use of its discoveries. Physics is of global relevance, and, as such, is a global collaboration. We should acknowledge the past, learn from it, and move forward with a positive attitude to the future.

1.24 The Physics curriculum should be inclusive with activities that are accessible to all students. Where this is not possible, suitable alternatives should be provided to allow all students to meet the learning outcomes, while maintaining a sense of belonging and acceptance. Through the curriculum, students will build an awareness of EDI to enable them to accept and support their peers and their staff, and to be equipped as graduates to enter the employment arena and work in a professional manner. The curriculum should not have any compulsory or optional elements where some students are discriminated against, or made unwelcome or unsafe. For example, when planning placement and field trip locations, care should be taken to verify that there is minimal risk of discrimination on the basis of protected characteristics.

1.25 The principles of equity, diversity and inclusion are effectively maintained when all individuals are offered the same opportunities and share the same responsibilities to embody them in their practice. EDI principles should appear throughout learning, teaching, practicing and supporting Physics, and permeate the staff and student environments.

1.26 Positive steps should be taken to eradicate harmful stereotypes and language, to remove barriers to inclusivity, and to challenge systemic and structural disadvantages impacting specific cultural or social groups. Ways to achieve this include partnerships between students and staff, empowering all to make meaningful contributions in a respectful environment. All are responsible for building an inclusive culture.

Accessibility and the needs of disabled students

1.27 Accessibility involves enabling access for people with differing individual requirements, eliminating unnecessary barriers to successful learning and assessment. Physics courses can give all students the opportunity to thrive, maintaining a sense of belonging and acceptance; students must be offered learning and assessment opportunities that are equally accessible to them, by means of inclusive design wherever possible and by means of reasonable individual adjustments where necessary.

1.28 Inclusive design is defined as any process that anticipates the requirements of all students in the design, delivery and assessment of the curriculum and all processes that involve students from matriculation to graduation. The aim of inclusive design is to allow all students to participate fully in all learning and assessment activities.

1.29 Entry to Physics courses should be equitable and not influenced by any perceptions by staff or students of barriers to learning.

1.30 Course teams should take full advantage of the guidance and interpretation of legislative principles by the Disabled Student Commitment and ensure that all students are provided with appropriate and inclusive support and training to develop the key knowledge skills and behaviours outlined in this Statement. It is important for course teams to consider the accessibility of their communications to students. Particular attention should be given to the accessibility of mathematical and graphical content, and laboratories which are essential to the discipline. Flexibility of delivery can improve accessibility to learning for a diverse community. A mix of synchronous and asynchronous delivery can be beneficial for a broad range of learners who may face barriers, especially, but not restricted to, disabled and neurodivergent students.

1.31 Adaptive technologies are important in removing barriers to access and are rapidly developing. However, at the time of writing, mainstream adaptive technologies do not effectively support mathematical and diagrammatical content that are critical to the discipline. Higher education providers should provide the resources necessary to mitigate these limitations.

1.32 All practical efforts should be made to ensure equal access to extracurricular activities such as placements and volunteering opportunities, given the additional challenges faced by some students and the hidden costs often involved.

1.33 Physics course teams engage with students and with the relevant student support services to discuss and implement reasonable individual adjustments where necessary.

1.34 Higher education providers should ensure Physics course teams have the appropriate training and resources to implement accessibility in practice.

Education for sustainable development

1.35 Physics is central to the United Nations Sustainable Development Goals (UN SDGs) relating to the physical world. Physics students acquire valuable subject knowledge related to the SDGs, as well as a wide range of transferable skills. Throughout their studies, Physics students gain experience in critically analysing information and drawing conclusions based on data. The ability to distil information, and formulate and tackle problems is critical to addressing almost all of the SDGs.

1.36 As well as providing an intellectual framework, Physics offers crucial instrumentation which provides data to quantify problems. Feeding this data into physical models guides potential solutions; these contributions occur in all SDGs which have a physical science component.

1.37 Physics underpins many of the current and emerging technologies that are required to achieve SDGs in areas such as energy, innovation, growth and health. For example, thermal and statistical physics is the foundation to the energy and climate SDGs, both in understanding the problems and framing (and constraining) approaches to solutions or mitigation technologies. The former is illustrated by the deduction of paleotemperatures from ice cores. The latter is illustrated by the limitations on current development of the most efficient multi-stage photocells to generate clean power. An example which has already had an immense impact in energy consumption is the invention of light-emitting diodes (LEDs) which have a 75% reduction on the waste heat emitted from conventional incandescent bulbs.

1.38 Physics students are trained to communicate in clear, concise language. Communication of complex information to both specialist and general audiences is needed to tackle global challenges which cover diverse topics.

1.39 The broad skills developed during a Physics degree allow Physics graduates to pursue a diverse range of careers. Embedding knowledge of the SDGs in the Physics curriculum ensures that graduates entering a wide variety of fields are equipped to contribute to solutions for a more sustainable world. Embedding may be achieved using appropriate examples on problem sheets, having project work on addressing sustainability themes or providing lectures on sustainability subjects – with the possibility of collaboration with other higher education departments, or external bodies.

Employability, enterprise and entrepreneurship education

1.40 Enterprise is the generation of novel ideas and their application to create practical action, combining creativity, innovation, adaptability, problem solving, communication and reflective practice. Entrepreneurship is acting on novel ideas and opportunities to create cultural, social or economic value. Employability is the combination of skills, knowledge and behaviours that helps individuals become more likely to gain employment and succeed in their chosen careers.

1.41 Enterprise and entrepreneurship education supports skills, knowledge, and behaviours, that are likely to have a significant impact on the individual student in terms of their career awareness and future career success, benefitting themselves, society and the economy.

1.42 Physics graduates are valued for their innovative and analytical approaches to problem solving and their wide range of transferable skills, as detailed in this document. Physics graduates go on to employment in many sectors, including technology, healthcare, IT, finance, management and education. Their work may encompass fast-growing or emerging technology sectors, including renewable energies, the space industry, artificial intelligence and machine learning, and financial technology.

1.43 Physics course teams should engage with students and relevant careers advisers to help students understand and articulate the value of the skills, knowledge and behaviours gained from a Physics degree and how the Physics degree aligns with work-based learning opportunities or graduate careers.

1.44 Physicists contribute to new inventions in fields including applied photonics, biotechnology, digital communication, metrology, quantum computing and renewable energy generation. Enterprise and entrepreneurship education empowers Physics graduates to increase the social and economic impact of their work through research and development, commercialisation and spinouts.

1.45 Physics courses may offer students opportunities to develop and demonstrate entrepreneurial skills. This may include design thinking, innovation, project and risk management, business and financial awareness, as well as commercialisation. Where such topics are delivered, they will ideally be explored through applications of Physics.

1.46 Industrial partners, alumni, entrepreneurs and other relevant specialists may be invited to contribute to curricular and co-curricular activities or to provide input to guide the evolution of Physics courses through external advisory boards. External input is valuable in emphasising the importance of skills related to employability, enterprise and entrepreneurship, and in providing appropriate vision so that teaching, learning and assessment is as authentic as possible.

Generative artificial intelligence

1.47 Generative artificial intelligence (GenAI) is rapidly developing, and, as such, this section gives guiding principles (rather than specific recommendations) for incorporating GenAI tools within the curriculum.

1.48 Physics has contributed to the development of machine learning and artificial intelligence. The discipline uses and develops deep learning and neural networks to process experimental data and model systems. GenAI has the potential to enhance productivity in many areas of life. Students need to be prepared to use it in their studies and future employment, but they need careful guidance, training and practice within the curriculum to develop strategies for using GenAI in ethical and effective ways.

1.49 GenAI generates text, images, video, computer code, and other outputs yet to be developed. This impacts on the skills required of a Physics graduate in the workplace and hence on the skills, activities and learning outcomes central to a Physics degree. As with other technological advances, this should be embraced while maintaining an awareness of the risks and limitations.

1.50 The availability of AI tools impacts learning outcomes and assessment. This requires the development of assessment protocols directly testing the use of GenAI. Assessments that recognise the potential of GenAI in Physics, develop students' critical thinking, and equip them with the ability to solve complex problems creatively should be welcomed.

1.51 Students should learn to use GenAI responsibly, ethically and safely. Care should be taken to ensure that sensitive data is not released into the public domain. For example, there may be issues with general data protection regulation and intellectual property. Students should also be trained to critique the output from any GenAI tool regarding accuracy, relevance or bias.

2 Distinctive features of the Physics degree

Design

2.1 Physics is a broad subject, leading to a variety of Physics degree courses, including joint honours degrees and Physics with a specialism. There is, however, a common core to most Physics degrees outlined in paragraph 1.15. The physics components of the degree which are beyond the core usually reflect the research strengths and interests of each higher education provider. Examples are provided in paragraph 1.16.

2.2 Many Physics degrees incorporate placements in industry, within university research groups, in scientific areas in publicly-funded bodies such as health services or national research laboratories, or in other professional environments. These may be purely experiential and non-accredited, or count towards the degree classification, and/or be acknowledged by a certificate.

Progression

2.3 Over the course of a standard undergraduate degree with honours (FHEQ Level 6; FQHEIS Level 10) or, if available, an integrated master's degree (FHEQ Level 7; FQHEIS Level 11) a Physics student will progress from one level of study to the next, in line with the regulations and processes for each institution. (The QAA document The Frameworks for Higher Education Qualifications of UK Degree-Awarding Bodies defines the levels of qualifications.) However, it is expected that each level would see the attainment of knowledge, expertise and experience that builds towards the final achievement of meeting the threshold subject-specific and generic skills listed in this Statement. This will usually include successful completion, reflecting sufficient credit (including any practical component) for the award of a degree.

2.4 Upon graduation from an undergraduate degree, it would be expected that a student who had achieved a second-class degree or higher would be capable of, and equipped for, undertaking postgraduate study in Physics, Astronomy, Astrophysics or a related discipline. Entry requirements to postgraduate courses are, however, determined by individual providers and may require specified levels of achievement at undergraduate level.

2.5 Undergraduates studying Physics, Astronomy and Astrophysics courses as part of a combined or joint degree with other subjects (including courses that specify major and minor options) will achieve core elements of the specific and generic skills outlined in this Statement and will add others according to the areas covered in the other subject(s) of their degree. Additionally, they may explore the overlap between different disciplines, creating further opportunities for interdisciplinary study.

2.6 Students enrolled in a standard undergraduate honour's degree course in Physics, Astronomy or Astrophysics who exit their courses earlier may be eligible for a Certificate of Higher Education (FHEQ Level 4; FQHEIS Level 8), a Diploma of Higher Education (FHEQ Level 5; FQHEIS Level 9), or other awards depending upon the levels of study completed to a satisfactory standard.

Flexibility

2.7 At providers in England, Wales and Northern Ireland, the duration of a full-time course leading to a standard undergraduate degree is three years, or four years for an integrated master's degree. In Scotland, bachelor's degrees with honours are typically designed to include four years of study and integrated master's five, which reflects the structure of Scottish secondary education.

2.8 Students following part-time routes accumulate academic credit in proportion to the schedule of their study, and their total study time and credit value would be the equivalent of those achieved on full-time routes.

2.9 Higher education providers structure the courses they offer to support students' learning and attainment. Depending on the educational mission of the provider, this may include opportunities to engage in learning on campus, online, and/or through hybrid learning, arranged in terms, by semester, year-long, block or other formats. These may be offered in full and/or part-time modes of study and credit may be accumulated through the completion of micro-credentials, short-accredited learning, recognition of prior learning or the accreditation of prior experiential learning.

2.10 For students who do not have the required qualifications, some higher education providers offer alternative pathways onto a Physics degree. This can include entry via an access programme or Foundation Year, which in some institutions is organised as an alternative route into a range of science or engineering subjects, including Physics.

Partnership

2.11 Higher education providers may partner with external organisations to provide students with broader opportunities during their period of study. These partnerships may allow students either to study at a different institution, typically overseas, or spend time in industry gaining relevant work experience.

2.12 The amount of credit associated with a period of study abroad will reflect the duration and the regulations of the home provider. In addition to broadening the horizons of the student, any credit earned during the time spent studying abroad will contribute towards progression. In cases where the marks awarded by the partner contribute to the student's final degree classification, these should be carefully calibrated to ensure equivalence to the awarding institution.

2.13 Professional placements with partners in the industrial, commercial, government and not-for-profit sectors can provide credit-bearing and/or experiential opportunities for students, varying from a short-term placement to complete a specific project to a full year in industry (see paragraph 2.2). There is direct value of these partnerships for students and for partners, with an emerging curriculum encouraging the incorporation of contemporary applications of Physics.

Monitoring and review

2.14 Physics degrees are routinely reviewed both externally and internally, and the student voice forms an important part of this. Reviews draw on a range of external reference points, including this Statement, to ensure that the provision aligns with sector norms.

2.15 The external examining system in use across the UK higher education sector ensures consistency in academic standards. Typically, external examiners will be asked to comment on the types, principles and purposes of assessments being offered to students. They will consider the types of modules on offer to students, the outcomes of a cohort and how these compare to similar provision offered within other UK higher education providers. External examiners produce a report each year and make recommendations for changes to modules and assessments (where appropriate). Subject Benchmark Statements can play an important role in supporting external examiners in advising on whether threshold standards are being met in a specific subject area.

2.16 Externality is an essential component of the quality assurance system in the UK. Providers may use external reviewers, who may be current or past external examiners, as part of periodic review to gain an independent perspective on any proposed changes and ensure threshold standards are achieved and content is appropriate for the subject. Many Physics, Astronomy and Astrophysics degrees undergo an Accreditation review by the Institute of Physics.

3 Content, structure and delivery

3.1 This section explores how the content of the curriculum for Physics shapes the likely teaching and learning strategy and the modes of assessment that allow students to demonstrate they have met the benchmark standards and discriminate between different levels of attainment.

Content and teaching

3.2 Physics is a hierarchical discipline that lends itself to 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, experiment and observation, are developed. This leads to teaching methods (which may be in-person and/or online, synchronous and/or asynchronous as appropriate) that may include:

- lectures supported by problem-solving classes and group tutorial work
- laboratory work (when appropriate)
- observational work in Astronomy (when appropriate)
- the use of textbooks, electronic resources and other self-study materials
- open-ended project work, some of which may be team-based
- activities devoted to generic and subject-specific skills development
- placements/visits to schools, or industrial or other research facilities.

3.3 The balance between these methods may vary between providers, courses and modules, and the optimum combination will evolve with time due to, for example, advances in technology and pedagogical thinking.

3.4 Approaches to skills development encompass both generic and subject-specific skills. These should, where appropriate, be developed with reference to applications in Physics. Development between levels of study may be evident; for example, laboratory (and observational) work may become open-ended with more demanding reporting criteria at the higher levels.

3.5 Computer skills may include programming and the use of software packages for simulation, computer algebra, data analysis and the utilisation of GenAI. Skills may also be developed in the use of computers for the control of experiments and the acquisition of data.

3.6 Teaching and learning strategies are designed to provide students with appropriate subject knowledge, understanding, abilities and academic and professional skills especially valued by quantitative professions which employ physicists. Many of these skills are transferable into both quantitative and other more general careers.

3.7 This Subject Benchmark Statement does not aim to be prescriptive about which teaching or learning methods are used by a particular course. Higher education providers use appropriate teaching methods to ensure that students are engaged, motivated and challenged to learn as well as delivering the course learning outcomes. Attention should be paid in the design process to ensure that teaching methods support achievement of the learning outcomes and are inclusive and accessible to all students.

Assessment

3.8 The assessment of students aligns with defined learning outcomes and is appropriate to the knowledge and skills to be developed. In this way the integrity, robustness, accessibility and diversity of the assessment can be assured.

3.9 A variety of assessment methods are appropriate within Physics courses, including:

- time-constrained examinations
- closed-book and open-book tests
- computerised adaptive testing
- problem-based assignments
- laboratory books and reports
- observation of practical skills
- individual project reports (including placement or case-study reports)
- team project reports
- presentations and/or posters
- appropriately arranged viva voce interviews
- essays
- project artefacts such as computer programmes, equipment, electronic circuits, videos or websites
- uses (and critical assessment) of outputs from GenAI
- educational resources from academic educational research used for teaching in higher education, schools and outreach
- reflective analysis
- peer and self-assessment.

3.10 Physics courses will typically employ different styles of assessment to test different learning outcomes. For example, examination and test questions may be used to assess understanding of concepts and the ability to develop mathematical models, complete calculations, solve new problems and communicate physical arguments. Some elements of time-constrained assessment may have a role in testing a student's capacity to organise work and to think and communicate under proscribed conditions. These will be augmented by other methods which include reports, presentations and reflective accounts. Such activity is often more appropriate for assessing skills such as – but not limited to – project planning and execution, use of software, enterprise and entrepreneurship, communication, teamwork and research.

3.11 The performance of an individual student may vary significantly between modules and the student's marks on some modules may not be commensurate with their overall performance. This is an inherent feature of quantitative subjects and reflects both the conceptual difficulty and the need to solve quantitative problems. In assessments that include significant amounts of problem-solving, frequently requiring extensive use of mathematics, marks often span the entire range of an assessment continuum. Students towards the lower end of the performance range may fail some modules while still meeting the overall learning outcomes of the course. Assessment regulations need to be flexible enough to take account of the variability, with providers allowing examiners to judge overall performance within the context of all learning outcomes.

4 Benchmark standards

Introduction

4.1 This Subject Benchmark Statement sets out the minimum threshold and typical standards that a student will have demonstrated when they are awarded an honours degree in Physics, Astronomy and Astrophysics. Demonstrating these standards over time will show that a student has achieved the range of knowledge, understanding and skills expected of graduates in Physics, Astronomy and Astrophysics.

4.2 The vast majority of students will perform significantly better than the minimum threshold standards. Each higher education provider has its own method of determining what appropriate evidence of this achievement will be and should refer to Annex D of the Frameworks for Higher Education Qualifications of UK Degree-Awarding Bodies. This Annex sets out common descriptions of the four main degree outcome classifications for bachelor's degrees with honours: 1st, 2.1, 2.2 and 3rd.

Threshold level

Subject knowledge, understanding and skills

4.3 On graduating with an honours BSc degree in Physics, Astronomy or Astrophysics, students should be able to:

- understand and apply basic physical laws and principles
- identify and use relevant physical laws and principles when dealing with simple problems
- execute and analyse the results of an experiment (if on an experimental course), with an appreciation of the safe use of basic apparatus
- competently use appropriate software packages/systems for the analysis of data, simulation of physical systems and the retrieval of appropriate information
- undertake numerical manipulation of data and to present and interpret information graphically
- perform an investigation and analyse the results. Such analysis will include the evaluation of the level of uncertainty or limitation in the results
- communicate scientific information, typically through a selection of visualisation, scientific reports and/or presentations, suitable for a variety of audiences
- articulate the value of the skills, knowledge and behaviours gained from a Physics degree.

Generic skills

4.4 On graduating with an honours degree in Physics, Astronomy or Astrophysics, students should be able to:

- identify issues, questions and problems
- identify gaps in their own knowledge and acquire new knowledge
- understand and analyse knowledge and information
- synthesise the state of knowledge on a particular topic

- apply knowledge and understanding to provide evidenced conclusions
- communicate effectively and appropriately
- present knowledge or an argument in a way that is comprehensible to others
- work with a range of data, including qualitative and quantitative empirical data
- critically engage with a range of forms of digital technology to collate, analyse, select and present information
- assert intellectual independence, including undertaking tasks independently (with appropriate guidance and support), conducting self-directed research and demonstrating critical judgement
- work collaboratively, including undertaking work in a group or team and/or participating in discussions, showing an appreciation for diversity within the group.

Typical level

4.5 A graduate who has reached the bachelor's degree with honours typical level has demonstrated the capabilities and skills of the threshold honours degree level and, in addition, competence in:

- the application of physical principles to diverse areas of Physics
- the solution of problems in Physics by selecting and using appropriate mathematical and physical techniques
- making appropriate approximations when solving problems
- critical analysis of the results of an experiment or investigation, evaluation of their significance and setting them in context, including a comparison of the results with expected outcomes, theoretical and computational models or published data
- the design and execution of effective experiments (if on an experimental course)
- use of mathematical and computational techniques and analysis to model physical behaviour
- clear and accurate communication of scientific information to different audiences
- management and use of research-based materials
- where appropriate, an appreciation of topics related to enterprise and entrepreneurship - for example, with design thinking, innovation, project and risk management, business and financial awareness, and commercialisation.

Integrated master's

4.6 A graduate who has reached the integrated master's degree with honours threshold level has demonstrated the capabilities and skills of the typical BSc with honours level and will also have:

- a working knowledge of a variety of experimental, mathematical and/or computational techniques applicable to current research or applications in Physics
- undertaken an extended investigation
- encountered research-level material.

4.7 A graduate who has reached the integrated master's degree with honours typical level has demonstrated the capabilities and skills of the integrated master's threshold level and in addition an ability to:

- apply fundamental laws and principles to a variety of areas in Physics, some of which are at (or are informed by) the forefront of the discipline
- apply relevant, recent, research to current questions in Physics
- interpret and contextualise mathematical descriptions of physical phenomena
- plan and execute an open-ended extended research project or investigation, demonstrating some originality
- show the competent use of specialised equipment or research grade software or methods
- master new techniques in a theoretical, computational or experimental context
- communicate complex scientific ideas, including the concise, accurate and informative conclusions of an experiment, investigation or project
- demonstrate an understanding of scientific research and propose realistic suggestions as to how it may progress further.

5 List of references and further resources

Advance HE and QAA (2021) Education for Sustainable Development Guidance
www.qaa.ac.uk/quality-code/education-for-sustainable-development

QAA (2018) Enterprise and Entrepreneurship Education: Guidance for UK Higher Education Providers
www.qaa.ac.uk/quality-code/enterprise-and-entrepreneurship-education

QAA (2018) Quality Code Advice and Guidance
www.qaa.ac.uk/the-quality-code/advice-and-guidance

QAA (2024) The Frameworks for Higher Education Qualifications of UK Degree-Awarding Bodies
www.qaa.ac.uk/docs/qaa/quality-code/qualifications-frameworks.pdf

QAA (2024) The UK Quality Code for Higher Education
www.qaa.ac.uk//en/the-quality-code

6 Membership of the Advisory Group

Membership of the Advisory Group for the Subject Benchmark Statement for Physics, Astronomy and Astrophysics 2024

Professor Mike Gunn (Chair)	University of Birmingham
Professor Mervyn Roy (Deputy Chair)	University of Leicester
Professor Alison Voice (Deputy Chair)	University of Leeds
Dr Charles Barton	University of York
Nadira Begum	QAA Coordinator
Dr Nicholas D'Ambrumenil	University of Warwick
Miss Robyn Henriegel	Institute of Physics
Dr Robert Jeffrey	University of Southampton
Professor Philip Jones	University College London
Professor David Joss	University of Liverpool
Dr Nicolas Labrosse	University of Glasgow
Dr Victoria Mason	Discovery Planet CIC
Professor Andrew Newsam	Liverpool John Moores University
Dr Kevin O'Keeffe	Swansea University
Dr Philippa Petts	Durham University
Professor Danny Saunders	QAA Officer
Dr Julie Wardlow	University of Lancaster
Dr Ian Whittaker	Nottingham Trent University
Professor Andrei Zvelindovsky	University of Lincoln

Membership of the Advisory Group for the Subject Benchmark Statement for Physics, Astronomy and Astrophysics 2019

Professor Michael Edmunds (Chair)	Cardiff University
Simon Bullock	QAA Officer
Dr Mark Everitt	Loughborough University
Dr Alison Felce	QAA
Professor Fitzsimmons Alan	Queen's University, Belfast
Robyn Henriegel	Institute of Physics
Professor Robert Lambourne	The Open University

Membership of the Advisory Group for the Subject Benchmark Statement for Physics, Astronomy and Astrophysics 2008

Professor Michael Edmunds (Chair)	Cardiff University
Professor Susan Cooper	University of Oxford
Dr Nick D'Ambrumenil	University of Warwick
Dr Richard Bacon	University of Surrey
Robyn Henriegel	Institute of Physics
Professor James Hough	University of Hertfordshire
Dr Robert Lambourne	The Open University
Professor Andrew Long	University of Glasgow
Professor Peter Main	Institute of Physics
Professor Richard Thompson	Imperial College London
Dr Alison Voice	University of Leeds

Membership of the Advisory Group for the Subject Benchmark Statement for Physics, Astronomy and Astrophysics 2002

Dr Edward Slade (Chair)	University of Keele (until July 2001)
Dr Nick d'Ambrumenil	University of Warwick
Dr Craig Adam	Staffordshire University
Professor Mick Brown	University of Cambridge
Mr Philip Diamond	Institute of Physics
Professor Michael Edmunds	University of Wales, Cardiff
Professor Peter Main	University of Nottingham
Dr Tony Phillips	University of Manchester
Professor David Saxon	University of Glasgow
Dr Alison Voice	University of Leeds
Dr Robin Walker	University of Bristol
Dr Nicola Wilkin	University of Birmingham
Professor John Young	Sheffield Hallam University

Fourth edition

Published - 9 October 2024