The University Of Sheffield.

Programme Specification

A statement of the knowledge, understanding and skills that underpin a taught programme of study leading to an award from The University of Sheffield

Programme Details

1. Programme title	Physics with Particle Physics
2. Programme code	PHYU44
3. QAA FHEQ level	7
4. Faculty	Science
5. Department	Physics and Astronomy
6. Other departments providing credit bearing modules for the programme	None
7. Accrediting Professional or Statutory Body	Institute of Physics
8. Date of production/revision	June 2022

Awards	Type of award	Duration
9. Final award	MPhys	4 years
10. Intermediate awards	BSc (exit award)	3 years

Programme Codes

11. JACS code(s) *Select between one and three codes from the HESA website.*	F370	F300	
12. HECoS code(s) *Select between one and three codes from the HECoS vocabulary.*	101077	100425	

Programme Delivery

13. Mode of study	Full-time
14. Mode of delivery	Face-to-face (on campus)

15. Background to the programme and subject area

Physics is the most fundamental of all the sciences: not only is it a fruitful research discipline in its own right, but its ideas and techniques underpin developments in many other areas of science, technology and medicine. It is characterised by the use of a few basic principles, quantities and laws to describe, understand and predict the behaviour of relatively complex systems, both natural and artificial. The key features of physics are the modelling of natural phenomena by means of mathematical equations (“theory”) and the making of experimental or observational measurements which both test existing theories and inspire new ones (“experiment”). The interplay of theory and experiment drives the development of the field, and requires a broad range of skills including mathematical modelling, problem solving, experiment design and data analysis, teamwork and communication. Thus, in addition to the intrinsic interest of the subject, a degree in Physics provides a wide range of analytical, problem solving and communications skills, which make Physics graduates highly employable across a broad spectrum of fields in industry, commerce, research and education.

Particle physics concerns itself with the fundamental structure of matter: the elementary particles and the forces between them. The Department has a strong and diverse research programme in experimental particle physics, ranging from exploring the high-energy frontier with the ATLAS experiment at the LHC through neutrino physics to direct searches for dark matter. Experimental particle physics is typically carried out in large international collaborations and requires skills in teamwork, communications, programming and statistical analysis of very large data samples, all of which are valuable attributes of any graduate.

The MPhys in Physics with Particle Physics aims to equip students with a thorough knowledge of the fundamental principles of physics and associated mathematical techniques. In addition, it gives students the opportunity to study and research topics at the edge of the discipline of experimental particle physics and in doing so gives them the best preparation for PhD study, careers as a professional physicist or related technical careers. Topics in nuclear and particle physics and astrophysics are introduced in year 1 and play an increasingly important role at higher levels, culminating in a substantial research project in the final year.

16. Programme aims

MPhys Physics with Particle Physics aims, as with all MPhys programmes in the Department,	
A1	to provide teaching that is informed and invigorated by the research and scholarship of the staff and is stimulating, useful and enjoyable to students from a wide variety of educational backgrounds.
A2	to produce graduates with well-developed practical, analytical, communication, IT and problem-solving skills who readily find employment in industry, the professions and public service.
A3	to address a wide diversity of student interests and aspirations through degree programmes which retain flexibility and choice while furnishing a well-rounded understanding of the subject.

A4	to encourage and develop our students' desire for learning and to support their development of appropriate interpersonal and transferable skills.
A5	to sustain a culture of teaching and research that is able to foster the free pursuit of knowledge and the rigorous, quantitative analysis of information.
A6	to provide, through the Foundation Year, access to our degree programmes for students with suitable levels of academic ability from non-traditional educational backgrounds.
A7	to produce graduates with an understanding of most fundamental laws and principles of physics, with emphasis on their applications in the field of particle physics.
A8	to prepare students for a professional career either within or outside the discipline.
A9	to develop students' ability to design and execute open ended investigations (including experiments), analyse the results using a variety of quantitative methods, and draw valid conclusions.
A10	to ensure that students can manage their own learning and study a topic independently with the aid of appropriate sources.
A11	to provide students with an overview of the field of particle physics, including an awareness of the diverse areas of investigation within the discipline and its relationship to the wider contexts of physics and society.
A12	to extend students' knowledge of particle physics and particle astrophysics to a level at (or informed by) the forefront of the discipline.
A13	to prepare students for a research degree or research-based career in particle physics or a related discipline.
A14	to develop students' ability to plan and execute an experimental or computational investigation, using ideas and techniques appropriate to research work in particle physics or particle astrophysics, and including critical and quantitative assessment of their own work and the work of others.
A15	to ensure that students can investigate a topic independently with the aid of research articles and other primary sources, and report their findings clearly, concisely and accurately.

17. Programme learning outcomes

Knowledge and understanding On successful completion of the programme, students will be able to demonstrate knowledge and understanding of:		
		Links to Aim(s)
K1	the fundamental laws and principles of physics and the ways in which they are used to interpret the behaviour of natural phenomena and/or technology.	A1, A3, A7, A11
K2	the application of laws and principles along with experimental, mathematical and/or computational techniques to solve simple and open ended physics problems.	A2, A3, A4, A5, A9
K3	the empirical nature of physical science, the interplay between theory and experiment and the ethics of science in society.	A1, A5, A8, A9, A11

K4	methods of determining the uncertainty of experimental and/or computational investigations and the use of such error analyses in interpreting experimental results.	A2, A5, A9
K5	how to apply knowledge in all the basic areas of physics i.e. classical and quantum mechanics, thermal physics, wave phenomena, properties of matter, electromagnetism and statistical physics.	A2, A3, A7
K6	how to apply physics knowledge in particle physics and particle astrophysics to a level at, or informed by, the forefront of the discipline.	A1, A11, A12, A13
K7	advanced topics in particle physics and particle astrophysics to a level appropriate as a foundation for postgraduate research.	A11, A12, A13, A14
K8	current research and advanced scholarship in particle physics and particle astrophysics.	A8, A10, A11, A12, A13, A15
K9	key developments, experimental, computational or analytical techniques (dependent on programme) and background literature in the subject area of their level 4 research project in particle physics.	A8-A15
Skills and other attributes On successful completion of the programme, students will be able to:		
S1	analyse and solve problems in physics by identifying the appropriate physical principles, developing a mathematical model of the system and using appropriate mathematical techniques to obtain a solution.	A2, A7, A8, A9, A12, A13, A14
S2	use mathematics to analyse a physical system so as to deduce its behaviour and properties.	A2, A7, A8, A9, A12, A13, A14
S3	create, plan and execute an authentic open ended research investigation in the field of particle physics or particle astrophysics, including the ability to analyse the results quantitatively in order to draw conclusions and compare with expected outcomes.	A8, A9, A13, A14
S4	communicate scientific ideas and the results of investigations clearly and concisely, both orally and in writing, with consideration for the needs of the audience.	A2, A4, A8, A9, A13-15
S5	apply scientific computing (using languages such as Python) to analyse data, control experiments, undertake numerical simulation or analyse physical or mathematical systems.	A2, A4, A7, A8, A9, A12, A13, A14
S6	apply word processing, graphing and presentation software to communicate the results of an investigation through scientific written reports and oral presentations.	A2, A4, A8, A9, A13-15
S7	plan and manage personal learning, including time management skills, adapt to change, and be able to learn effectively using a wide variety of sources (lectures, textbooks, websites, etc.).	A2, A4, A8, A9, A10, A13-15

S8	work effectively as a member of a group by taking due consideration of others in order to communicate, plan tasks and encourage and support the group.	A2, A4, A8, A13
S9	safely use laboratory equipment to make experimental observations and measurements in order to explore physics concepts and execute experimental investigations.	A2, A8, A9, A13, A14
S10	analyse, summarise and synthesise primary or review papers in scientific journals, as well as other appropriate sources, as part of an investigation in a field relating to particle physics.	A2, A4, A10, A13-15
S11	plan and execute independent project work in a field related to particle physics to create new scientific knowledge in a research environment;	A13-15
S12	summarise and present the results of research-level investigations both orally and in written reports.	A2, A4, A8, A13-15
S13	apply advanced, specialised laboratory equipment and/or computational techniques relevant to research areas at the forefront of the discipline of particle physics and the ability to master, with training, new techniques.	A2, A4, A13-15
S14	make use of high level computer languages and, where appropriate, the ROOT analysis framework, to solve scientific programming problems, analyse large and complex data samples, develop simulations, or make use of existing multi-author software packages, as appropriate to their final-year research project.	A13-15

18. Learning and teaching methods

This programme is essentially a guided route through the MPhys Physics programme, and the approaches to teaching and learning are those employed in that programme. To summarise:

- Factual information is provided primarily through traditional 50-minute lectures, supplemented by material provided on Blackboard (e.g. copies of lecture notes, links to recommended reading, Encore lecture capture). Lectures take place within the University's centrally managed lecture theatres.
- In years 1 and 2 this is supplemented by regular small-group tutorials which help students develop their problem-solving skills and foster their development as physicists. Academic tutorials normally take place in tutors' offices, to facilitate the development of a supportive relationship between tutor and tutees.
- In years 1 and 2, part of the assessment for the core Physics programme is by portfolio, which encourages students to reflect on their learning, read and act on feedback, and become self-directed learners. In the portfolio, students use problem sets, lab work and other material from the course to evidence their achievement of learning outcomes. The portfolio is digitally curated by the students themselves. The portfolio is assessed by the student's academic tutor, so that any weaknesses exposed by interim assessments can be worked on through tutorials. In this way, students are provided with the support they need to develop as physicists and as active learners.
- The Department has an integrated teaching laboratory serving both first and second year practical classes, with an ample supply of University network PCs for data analysis, graph plotting etc. In year 1, records from some lab sessions form part of the portfolio, while others are intended to provide students with the opportunity to develop their practical skills without the stress of knowing that the results will be assessed. In year 2, structured experiments in semester 1 lead on to more open-ended mini-projects in semester 2, encouraging students to become more self-directed and independent in their approach to practical work.

● Group work forms part of the core modules in years 1 and 2, and there are further opportunities for group work in years 3 and 4.

● In years 3 and 4, the taught material is more advanced, and all courses are taught by people with research experience in the relevant field. By this stage, students should have become competent self-directed learners following two years' experience in curating portfolios.

● The distinctive element of the Physics with Particle Physics programme is focused on years 3 and 4. Although there are minor additional core elements in years 1 and 2 (10 and 20 credits, respectively), the emphasis in the early years is in ensuring that students acquire the knowledge and skills expected of a Physics graduate (the degree is in the process of being accredited by the Institute of Physics). In years 3 and 4, students will conduct projects in the field of particle physics and will be exposed to specialist courses reflecting the diverse research interests of the Department's Particle Physics and Particle Astrophysics research group.

● Project titles offered in years 3 and 4 will cover a diverse range of project types, from practical laboratory work carried out in the particle physics group research labs through computational data analysis of real experimental data to simulation work. For computational projects, students will be provided with accounts on the group's local computer network offering specialist software packages, and training on their use will be given. Programming skills are an integral part of particle physics (and of physics in general), and throughout the programme students will be encouraged to develop and apply this skill set.

19. Assessment and feedback methods

Assessment
As with all programmes in the Department, the aim is to introduce students to a range of assessment styles and techniques so that all students are given the opportunity to show off their strengths. The traditional end-of-semester exam plays a key role, because it is an efficient and robust method of assessing factual knowledge and the ability to apply it to (relatively) simple problems, but it is supplemented by an array of different techniques depending on the nature and level of the module.

● As noted above, a key part of the assessment for the core Physics modules in years 1 and 2 is a portfolio, which assesses, using a range of written evidence, the extent to which students have met the learning outcomes of the module. A satisfactory portfolio is a necessary and sufficient condition for passing the module. Most of the individual components that make up the portfolio are assessed formatively as they are submitted, with feedback provided so that students can improve any unsatisfactory elements. A mid-semester interim assessment, also formative, checks that student portfolios are on track to be assessed as satisfactory and offers feedback to students who are falling short. The aims of the portfolio assessment are:

○ to ensure, by requiring submissions throughout the semester, that students acquire good study habits and time management skills;

○ to reduce anxiety associated with exams (since a satisfactory portfolio demonstrates that the student has met the module learning outcomes and is therefore a sufficient condition for a pass;

○ To encourage students to reflect on their learning and become more active and self-directed learners.

The portfolio is graded Pass/Fail, with Distinction available for exceptional performance.

● Other taught modules (optional modules in years 1 and 2 and all taught modules in years 3 and 4) typically combine an end-of-semester exam, normally providing the bulk of the summative assessment, with various forms of in course assessment including (but not limited to) homework exercises, class tests, Backboard tests, formative problems classes, essays and presentations. Most of these carry some weight in the summative assessment, but their primary purpose is to provide an opportunity for students to test their understanding of the material and receive feedback.

● Laboratory courses in years 1 and 2, and project modules in years 3 and 4, are assessed by a combination of contemporaneous records ("lab diaries"), formal written reports, presentations and viva voce examinations. In years 1 and 2, lab diary entries, lab homework assignments and one or more formal written reports form part of the student's portfolio, while a final written report is a component of the summative assessment. In year 3, project work is assessed by a combination of supervisor's assessment (backed up by the evidence of the student's lab diary), a final written report, and a viva voce examination. The major research project in year 4 also has an assessed literature review and project plan: these test the student's ability to evaluate critically current research and scholarship in the field and to plan an investigation (both descriptors of an F7 level qualification).

- In project work, regular meetings with the project supervisor provide opportunities for formative assessment and feedback. In years 1 and 2, lab demonstrators will provide advice and formative feedback during the experimental work, and the lab homework assignments, being part of the portfolio, are first assessed formatively before summative assessment of the whole portfolio at the end of the semester.

- The Department recognises that there is a certain amount of subjectivity involved in the assessment of essays and reports. To mitigate this, detailed marking guidelines and rubrics are provided to assessors (and are made available to students), and any essay or report which contributes a substantial amount (>20% of a 10-credit module) to a module grade is double-marked by a second assessor.

Where possible, items of summative assessment are marked anonymously in line with University policy. There are some cases, most obviously viva voce examinations, where this cannot be done, and some cases, especially level 1 and 2 assignments handed in at tutorials, where the purpose of the assessment is primarily formative and it is necessary for the tutor to identify the student in order to provide appropriate support.

Feedback
Students receive feedback through a variety of routes. Personal tutorials are scheduled after the publication of module results to provide students with an opportunity to reflect on their performance in their programme as a whole and to receive advice and feedback from their tutor. Most individual modules have elements of in-course assessment which are returned with written feedback in a number of forms: individual marginal notes on student submissions; detailed discussion of common errors provided on a separate feedback sheet; general whole cohort feedback offered in a subsequent lecture (along with explanations of any points that were clearly widely misunderstood). Some modules make use of Blackboard quizzes in which feedback is provided automatically by the Blackboard system. Feedback on in-course assignments is normally provided on a two to three-week timescale.

A particular feature of Physics degree programmes is the portfolio system in the core modules of years 1 and 2, which is designed to help students to make the best use of their feedback. The final portfolio must include a reflective document in which students explain and evidence how they have used feedback to improve their work.

20. Programme structure and student development

This programme is a guided route through the standard MPhys physics programme, designed to allow students with a particular interest in particle physics to tailor their programme to reflect that interest (while still retaining all the standard features of an accredited Physics degree). As a result, the balance between core and approved modules is tilted towards core, because students are expected to take those option modules that relate to their specialisation in particle physics. It should be noted that students may transfer from this programme to the equivalent Physics programme at any time: in all years the regulations for the Physics with Particle Physics programme are a valid subset of the regulations for the equivalent Physics programme.

Programme structure (see Programme Regulations for details)
The programme structure follows the standard Physics programme structure, with the following differences reflecting the specialised nature of the programme:

1. Some modules focusing on particle physics and/or particle astrophysics which are optional in

the standard programme are core in the Physics with Particle Physics programme.

2. Some lists of approved options are truncated to ensure greater focus on particle physics.

3. In project modules, students will be required to choose from a reduced list of projects relevant to particle physics and particle astrophysics. This will still provide students with a diverse range of projects, including lab-based experimental work, data analysis and simulation.

Student development
The programme aims to produce graduates who are well equipped to proceed into postgraduate study, especially in the field of particle physics. Our graduates will have well-developed practical, analytical, communication, IT and problem-solving skills and will therefore also readily find employment in industry, the professions and public service. To achieve this aim, the programme fosters skills development at all levels, starting with the portfolio system at levels 1 and 2 and proceeding to group and project work at levels 3 and 4. In parallel with this, students will develop their knowledge and understanding of physics as a whole and nuclear and particle physics in particular via a carefully designed programme of core and optional units, with the weighting of particle physics increasing through the levels as students master the core knowledge and skills presented in the first two years. The portfolios associated with the level 1 and 2 core, with their emphasis on feedback and reflection, aim to facilitate students' professional and personal development and help them to become mature and reflective learners.

Detailed information about the structure of programmes, regulations concerning assessment and progression and descriptions of individual modules are published in the University Calendar available online at http://www.sheffield.ac.uk/calendar/.

21. Criteria for admission to the programme

Detailed information regarding admission to programmes is available from the Departmental web page https://www.sheffield.ac.uk/physics/undergraduate/courses

The standard requirement for students offering A-levels is AAA, to include Maths and Physics. For alternative entry requirements please see
https://www.sheffield.ac.uk/undergraduate/courses/2021/physics-particle-physics-mphys

22. Reference points

The learning outcomes have been developed to reflect the following points of reference:

Subject Benchmark Statements
https://www.qaa.ac.uk/quality-code/subject-benchmark-statements

Framework for Higher Education Qualifications (2014)
https://www.qaa.ac.uk/docs/qaa/quality-code/qualifications-frameworks.pdf

University Strategic Plan
http://www.sheffield.ac.uk/strategicplan

Learning and Teaching Strategy (2016-21)
https://www.sheffield.ac.uk/polopoly_fs/1.661828!/file/FinalStrategy.pdf

23. Additional information

None

This specification represents a concise statement about the main features of the programme and should be considered alongside other sources of information provided by the teaching department(s) and the University. In addition to programme specific information, further information about studying at The University of Sheffield can be accessed via our Student Services web site at http://www.shef.ac.uk/ssid.