Programme Specification: Undergraduate

For students starting in Academic Year 2023/24

1. Course Summary

Names of programme and award title(s)	BSc (Hons) Astrophysics BSc (Hons) Astrophysics with International Year (see Annex for details)
Award type	Combined Honours
Mode of study	Full-time
Framework of Higher Education Qualification (FHEQ) level of final award	Level 6
Normal length of the programme	3 years; 4 years with the International Year between years 2 and 3
Maximum period of registration	The normal length as specified above plus 3 years
Location of study	Keele Campus
Accreditation (if applicable)	The UK Institute of Physics (IoP) has accredited this programme until 30th March 2027. For further details see the section on accreditation.
Regulator	Office for Students (OfS)
Tuition Fees	**UK students:** Fee for 2023/24 is £9,250* **International students:** Fee for 2023/24 is £18,800** The fee for the international year abroad is calculated at 15% of the standard year fee

How this information might change: *Please read the important information at http://www.keele.ac.uk/student-agreement/. This explains how and why we may need to make changes to the information provided in this document and to help you understand how we will communicate with you if this happens.*

** These fees are regulated by Government. We reserve the right to increase fees in subsequent years of study in response to changes in government policy and/or changes to the law. If permitted by such change in policy or law, we may increase your fees by an inflationary amount or such other measure as required by government policy or the law. Please refer to the accompanying Student Terms & Conditions. Further information on fees can be found at http://www.keele.ac.uk/studentfunding/tuitionfees/*

*** We reserve the right to increase fees in subsequent years of study by an inflationary amount. Please refer to the accompanying Student Terms & Conditions for full details. Further information on fees can be found at http://www.keele.ac.uk/studentfunding/tuitionfees/*

2. What is a Combined Honours programme?

NB: all students who study a science Principal subject are candidates for the degree of Bachelor of Science (with Honours) (BSc Hons) irrespective of their second Principal subject.

Combined Honours degrees are degrees that are taken in two different subjects, resulting in an X and Y degree title. If you are taking a Combined Honours programme, these will be the two subjects you applied for. These are referred to as your Principal Subjects.

In a Combined Honours degree you must take at least 135 credits in each Principal Subject (270 credits in total), accrued over all three levels of study, with at least 45 credits at each level of study (Levels 4, 5 and 6) in each of two Principal Subjects (90 credits per year). The remaining available credits can be filled with modules from these subjects or other subjects entirely.

As a Combined Honours student you can choose to study just one subject in your final year of study, taking a minimum of 90 credits in this subject. This will result in an X with Y degree title.

3. Overview of the Programme

Astrophysics is the application of Physics to understand how the Universe works. Is there an Earth-like planet around another star? Is there a black hole at the centre of every galaxy? Why is the expansion of the Universe accelerating? These questions present humankind with some of its greatest intellectual challenges. In addition to the subject knowledge, Astrophysics curriculum has incorporated number of transferable skills that can be widely exploited in research, education and in a wide variety of industrial sectors. This is evidenced by the wide range of positions being held by Keele Astrophysics graduates.

The three year Combined Honours Astrophysics programme at Keele aims to cover all of the topics which are defined as "Core Physics" by Institute of Physics (IOP) for all undergraduate Astrophysics degrees in the UK. On successful completion of the Astrophysics programme at Keele, students will be equally qualified and well prepared for postgraduate studies or graduate level employment.

All the required instruction in Mathematics and Computing to study Astrophysics is incorporated within the Astrophysics modules. We operate an open-door policy which enables students to have excellent and flexible access to staff to seek advice or feedback on their work. Activities in year 1 and 2 Laboratories are designed such that students should be able to develop necessary competence in laboratory activities by the end of year 2 and be able to undertake individual project or team project in year 3.

4. Aims of the programme

The broad aims of the programme are to enable you to:

- achieve a knowledge and understanding of the fundamentals of Astrophysics and be able to apply this knowledge and understanding to solving problems;
- develop competence in the application of mathematics and computing to physical problems;
- develop competence in laboratory activities by the end of year 2 and have undertaken project work both individually and within a team by the end of year 3;
- acquire a range of subject-specific skills including how to formulate and tackle problems in Astrophysics; how to plan, manage, execute and report the results of an investigation; how to use mathematics to describe the physical world; and how to deploy these skills to tackle issues within the subject;
- acquire a range of cognitive, generic and transferable skills including problem-solving skills, investigative skills, analytic skills, communication skills, IT skills, time management skills and interpersonal skills.

5. What you will learn

The intended learning outcomes of the programme (what students should know, understand and be able to do at the end of the programme), can be described under the following headings:

- Subject knowledge and understanding
- Subject specific skills
- Intellectual skills
- Key or transferable skills (including employability skills)

Subject knowledge and understanding

The subject knowledge in the Combined Honours Astrophysics programme is underpinned by a core (astro)Physics curriculum as set out by the Institute of Physics and includes the fundamentals of classical and quantum mechanics, electromagnetism, optics, thermodynamics, solid state, atomic and nuclear physics, together with the mathematics that is used to describe them.

Successful students will be able to demonstrate:

- knowledge of the fundamental principles of Astrophysics and competence in applying these principles to

diverse areas of the subject;
- the ability to solve problems in Astrophysics using appropriate mathematical tools including the ability to make sensible approximations;
- the ability to execute, and analyse critically, an experiment or investigation and draw valid conclusions. You will be able to estimate the level of uncertainty in your results and compare these results with expected outcomes, theoretical predictions or with published data. You will be able to evaluate the significance of your results in this context;
- If you specialise in Astrophysics, via major honours, in your final year you develop a wider knowledge and understanding of advanced topics and their applications and acquire skills in the critically reading and understanding published work in Astrophysics.

Subject specific skills

Successful students will have:

- the ability to work safely in a laboratory and to have a knowledge and awareness of standard safety procedures;
- a sound familiarity with laboratory apparatus and techniques;
- competent use of appropriate IT packages/systems for the analysis of data and the retrieval of information;
- an ability in numerical manipulation and estimation and the ability to present and interpret information graphically;
- an ability to use mathematical techniques and analysis to model physical behaviour;
- an ability to record and communicate scientific information, in particular through clear and accurate scientific reports;
- an ability to question, learn and assimilate knowledge and to evolve your views of the world in response to that new knowledge;
- an ability to contribute through research to the development of knowledge in Astrophysics;
- (if you Major in Astrophysics in your final year) an ability to acquire knowledge and understanding of science for yourself, and to work productively on scientific problems on an individual basis.

Intellectual skills

Successful students will be able to:

- analyse and solve problems;
- evaluate evidence and make critical judgements;
- interpret and critique text;
- interpret and critique mathematical and numerical information;
- abstract and synthesise information;
- develop a reasoned argument;
- assess contrasting theories, explanations and policies;
- take responsibility for your own learning and critique that learning.

Key or transferable skills (including employability skills)

Successful students will have the opportunity to develop:

- the ability to manage yourown learning and to makeappropriate use oftext books, research-based materials and other learning resources;
- the ability to find information and make responsible use of it;
- the ability to listen;
- the ability to make effective written and oral presentations;
- the ability to work with numerical data;
- the ability to make sensible estimates;
- an awareness of the costs and benefits of your actions the ability to work effectively with a variety of types of Information Technology;
- the ability to plan, manage, execute and report an investigation;
- the ability to learn and gain understanding;
- the ability to work effectively both as an individual and as part of a team;
- the ability to sustain motivation for an extended period of time;
- a recognition of your responsibilities as an individual and as part of a team, an organisation.

Keele Graduate attributes

Engagement with this programme will enable you to develop your intellectual, personal and professional capabilities. At Keele, we call these our ten Graduate Attributes and they include independent thinking, synthesizing information, creative problem solving, communicating clearly, and appreciating the social, environmental and global implications of your studies and activities. Our educational programme and learning environment is designed to help you to become a well-rounded graduate who is capable of making a positive and valued contribution in a complex and rapidly changing world, whichever spheres of life you engage in after your studies are completed.

Further information about the Keele Graduate Attributes can be found here: http://www.keele.ac.uk/journey/

6. How is the programme taught?

Learning and teaching methods used on the programme vary according to the subject matter and level of the module. They include the following:

- Lectures
- Tutorials
- Laboratory Classes
- Exercise/Problem-Solving Classes
- Individual Progress Interviews
- Problem Sheet Assignments
- Group and Individual projects
- Directed Reading and Independent Study
- Use of e-learning/the Keele Learning Environment (KLE)

Apart from these formal activities, students are also provided with regular opportunities to talk through particular areas of difficulty, and any special learning needs they may have, with their Academic Mentors or module lecturers on a one-to-one basis.

These learning and teaching methods enable students to achieve the learning outcomes of the programme in a variety of ways.

7. Teaching Staff

The Physics/Astrophysics academic staff exhibit a research profile with two main areas of expertise; astrophysics and condensed matter physics. Keele performs internationally renowned work in the fields of exoplanets, stellar physics (both observational and theoretical), high energy extragalactic astrophysics and in the study of soft condensed matter such as polymers and biological molecules. All research-active staff play a role in teaching and most also undertake administrative roles, either within our teaching or research activities. The teaching and research profiles of the staff that currently deliver the Physics with Astrophysics programme can be found at http://www.keele.ac.uk/physics/people/. Timetabled teaching is always lead by academic staff.

The University will attempt to minimise changes to our core teaching teams, however, delivery of the programme depends on having a sufficient number of staff with the relevant expertise to ensure that the programme is taught to the appropriate academic standard.

Staff turnover, for example where key members of staff leave, fall ill or go on research leave, may result in changes to the programme's content. The University will endeavour to ensure that any impact on students is limited if such changes occur.

8. What is the structure of the Programme?

The academic year runs from September to June and is divided into two semesters. The number of weeks of teaching will vary from programme to programme, but you can generally expect to attend scheduled teaching sessions between the end of September and mid-December, and from mid-January to the end of April. Our degree courses are organised into modules. Each module is usually a self-contained unit of study and each is usually assessed separately with the award of credits on the basis of 1 credit = 10 hours of student effort. An outline of the structure of the programme is provided in the tables below.

There are two types of module delivered as part of your programme. They are:

- Compulsory modules - a module that you are required to study on this course;
- Optional modules - these allow you some limited choice of what to study from a list of modules.

You are able to take up to 60 credits across your degree programme as Faculty Funded additional Modern Language modules in order to graduate with the Enhanced Degree Title. [Please see link for more information on Enhanced degree titles.]

For further information on the content of modules currently offered please visit:

https://www.keele.ac.uk/recordsandexams/modulecatalogue/

A summary of the credit requirements per year is as follows, with a minimum of 90 subject credits (compulsory plus optional) required for each year across both of your Principal Subjects. This document has information about *Astrophysics* modules only; please also see the document for your other subject.

Year	Compulsory	Optional		Electives	
		Min	Max	Min	Max
Level 4	60	0	0	0	0
Level 5	60	0	0	0	0
Level 6	30	30	30	0	0

In year 3 there is the option to choose to specialise in one of your subjects, taking a minimum of 90 credits in this subject rather than taking modules from both subjects.

Module Lists

Level 4

Compulsory modules	Module Code	Credits	Period
Mechanics, Gravity and Relativity	PHY-10022	15	Semester 1
Nature of matter	PHY-10024	15	Semester 1
Oscillations and Waves	PHY-10020	15	Semester 2
Electricity and Stellar Structure	PHY-10023	15	Semester 2

Level 5

Compulsory modules	Module Code	Credits	Period
Quantum Mechanics	PHY-20006	15	Semester 1
Optics and Thermodynamics	PHY-20027	15	Semester 1
Stellar Astrophysics	PHY-20002	15	Semester 2
Statistical Mechanics and Solid State Physics	PHY-20026	15	Semester 2

Level 6

Compulsory modules	Module Code	Credits	Period
Electromagnetism	PHY-30012	15	Semester 1
Astrophysics Group Project and Science Communication - ISP	PHY-30006	15	Semester 1-2

Optional modules	Module Code	Credits	Period
Polymer Physics	PHY-30010	15	Semester 1
Binary Stars and Extrasolar Planets	PHY-30024	15	Semester 1
Computational Methods in Physics and Astrophysics	PHY-30026	15	Semester 1
Data Analysis and Model Testing	PHY-30027	15	Semester 1
Particle Physics and Accelerators	PHY-30033	15	Semester 1
Two-Dimensional (2D) Materials	PHY-30037	15	Semester 1
Cosmology	PHY-30001	15	Semester 2
The Physics of Interstellar Medium	PHY-30002	15	Semester 2
The Physics of Compact Objects	PHY-30003	15	Semester 2
Quantum Physics of Atoms and Molecules	PHY-30009	15	Semester 2
Life in the Universe	PHY-30025	15	Semester 2
Quantum Mechanics II	PHY-30029	15	Semester 2
Physics of Fluids	PHY-30030	15	Semester 2
Atmospheric Physics	PHY-30031	15	Semester 2
Plasma Physics	PHY-30032	15	Semester 2
General Relativity, Black Holes and Gravitational Waves	PHY-30035	15	Semester 2

If you choose to specialise in this subject in your final year you will study the following modules:

Compulsory modules	Module Code	Credits	Period
Electromagnetism	PHY-30012	15	Semester 1
Astrophysics Group Project and Science Communication - ISP	PHY-30006	15	Semester 1-2
Dissertation	PHY-30017	15	Semester 1-2

Optional modules	Module Code	Credits	Period
Polymer Physics	PHY-30010	15	Semester 1
Binary Stars and Extrasolar Planets	PHY-30024	15	Semester 1
Computational Methods in Physics and Astrophysics	PHY-30026	15	Semester 1
Data Analysis and Model Testing	PHY-30027	15	Semester 1
Particle Physics and Accelerators	PHY-30033	15	Semester 1
Two-Dimensional (2D) Materials	PHY-30037	15	Semester 1
Cosmology	PHY-30001	15	Semester 2
The Physics of Interstellar Medium	PHY-30002	15	Semester 2
The Physics of Compact Objects	PHY-30003	15	Semester 2
Quantum Physics of Atoms and Molecules	PHY-30009	15	Semester 2
Life in the Universe	PHY-30025	15	Semester 2
Quantum Mechanics II	PHY-30029	15	Semester 2
Physics of Fluids	PHY-30030	15	Semester 2
Atmospheric Physics	PHY-30031	15	Semester 2
Plasma Physics	PHY-30032	15	Semester 2
General Relativity, Black Holes and Gravitational Waves	PHY-30035	15	Semester 2

Learning Outcomes

The table below sets out what students learn in the programme and the modules in which that learning takes place. Details of how learning outcomes are assessed through these modules can be found in module specifications.

Level 4

In Year 1 (Level 4) and Year 2 (Level 5) these learning outcomes are achieved in the compulsory modules which all students are required to take. Some of these outcomes may also be achieved or reinforced in elective modules together with other outcomes not stated here. In Year 3 (Level 6) the stated outcomes are achieved by taking any of the modules offered in each semester.

Subject Knowledge and Understanding	
Learning Outcome	**Module in which this is delivered**
Understand basic concepts in mechanics, nature of matter, oscillation and waves and electricity and stellar structure. Demonstration of this understanding by solving astrophysical problems. Understanding of mathematical techniques necessary for application to astrophysics. Perform practical work and keep accurate accounts of it, including professionally maintained records of purpose, methodology, and results. Communicate the process and results of practical work in formal, written presentations. Enter, manipulate, and present data with the aid of computer tools.	Oscillations and Waves - PHY-10020 Nature of matter - PHY-10024 Electricity and Stellar Structure - PHY-10023 Mechanics, Gravity and Relativity - PHY-10022

Subject Specific Skills	
Learning Outcome	**Module in which this is delivered**
The ability to work safely in a laboratory and to have a knowledge and awareness of standard safety procedures. A sound familiarity with laboratory apparatus and techniques. Competent use of appropriate IT packages/systems for the analysis of data and the retrieval of information. An ability in numerical manipulation and estimation and the ability to present and interpret information graphically. An ability to use mathematical techniques and analysis to model physical behaviour. An ability to record and communicate scientific information, in particular through clear and accurate scientific reports. An ability to question, learn and assimilate knowledge and to evolve your views of the world in response to that new knowledge. An ability to contribute through research to the development of knowledge in Astrophysics.	Nature of matter - PHY-10024 Electricity and Stellar Structure - PHY-10023 Oscillations and Waves - PHY-10020 Mechanics, Gravity and Relativity - PHY-10022

Key or Transferable Skills (graduate attributes)	
Learning Outcome	**Module in which this is delivered**
The ability to manage your own learning and to make appropriate use of text books, research-based materials and other learning resources. The ability to find information and make responsible use of it. The ability to listen. The ability to make effective written and oral presentations. The ability to work with numerical data. The ability to make sensible estimates. An awareness of the costs and benefits of your actions the ability to work effectively with a variety of types of Information Technology. The ability to plan, manage, execute and report an investigation. The ability to learn and gain understanding. The ability to work effectively both as an individual and as part of a team. The ability to sustain motivation for an extended period. A recognition of your responsibilities as an individual and as part of a team, an organisation	Mechanics, Gravity and Relativity - PHY-10022 Oscillations and Waves - PHY-10020 Nature of matter - PHY-10024 Electricity and Stellar Structure - PHY-10023

Level 5

Subject Knowledge and Understanding	
Learning Outcome	**Module in which this is delivered**
Comprehensive understanding of the relevant theoretical and experimental background of quantum mechanics, optics, thermodynamics, stellar astrophysics, statistical mechanics, and solid state physics.	Stellar Astrophysics - PHY-20002 Optics and Thermodynamics - PHY-20027 Quantum Mechanics - PHY-20006 Statistical Mechanics and Solid State Physics - PHY-20026
Can use range of established techniques for critical analysis of numerical calculations in connection with problems in quantum mechanics, optics, thermodynamics, stellar astrophysics, statistical mechanics and solid state physics.	Optics and Thermodynamics - PHY-20027 Stellar Astrophysics - PHY-20002 Statistical Mechanics and Solid State Physics - PHY-20026 Quantum Mechanics - PHY-20006
Extended abilities in the execution and reporting of laboratory work within the context of astrophysics.	Optics and Thermodynamics - PHY-20027
Experience of working in data reduction and analysis of astronomical data.	Stellar Astrophysics - PHY-20002

Subject Specific Skills	
Learning Outcome	**Module in which this is delivered**
The ability to work safely in a laboratory and to have a knowledge and awareness of standard safety procedures. A sound familiarity with laboratory apparatus and techniques. Competent use of appropriate IT packages/systems for the analysis of data and the retrieval of information. An ability in numerical manipulation and estimation and the ability to present and interpret information graphically. An ability to use mathematical techniques and analysis to model physical behaviour. An ability to record and communicate scientific information, in particular through clear and accurate scientific reports. An ability to question, learn and assimilate knowledge and to evolve your views of the world in response to that new knowledge. An ability to contribute through research to the development of knowledge in Astrophysics.	Optics and Thermodynamics - PHY-20027 Stellar Astrophysics - PHY-20002
Competent use of appropriate IT packages/systems for the analysis of data and the retrieval of information. An ability in numerical manipulation and estimation and the ability to present and interpret information graphically. An ability to use mathematical techniques and analysis to model physical behaviour. An ability to record and communicate scientific information, in particular through clear and accurate scientific reports. An ability to question, learn and assimilate knowledge and to evolve your views of the world in response to that new knowledge. An ability to contribute through research to the development of knowledge in Astrophysics.	Statistical Mechanics and Solid State Physics - PHY-20026 Stellar Astrophysics - PHY-20002 Quantum Mechanics - PHY-20006 Optics and Thermodynamics - PHY-20027

Key or Transferable Skills (graduate attributes)	
Learning Outcome	**Module in which this is delivered**
The ability to manage your own learning and to make appropriate use of text books, research-based materials and other learning resources. The ability to find information and make responsible use of it. The ability to listen. The ability to make effective written and oral presentations. The ability to work with numerical data. The ability to make sensible estimates. An awareness of the costs and benefits of your actions the ability to work effectively with a variety of types of Information Technology. The ability to plan, manage, execute and report an investigation. The ability to learn and gain understanding. The ability to work effectively both as an individual and as part of a team. The ability to sustain motivation for an extended period. A recognition of your responsibilities as an individual and as part of a team, an organisation.	Statistical Mechanics and Solid State Physics - PHY-20026 Stellar Astrophysics - PHY-20002 Optics and Thermodynamics - PHY-20027

Level 6

Subject Knowledge and Understanding	
Learning Outcome	**Module in which this is delivered**
Successful students will have gained an understanding of the central role played by the theory of electromagnetism in describing the universe and the world around them and be able to tackle problems and calculations in electromagnetism at a level appropriate to a final year honours degree course.	Electromagnetism - PHY-30012
Successful students will demonstrate the ability to work with and analyse astrophysical data and interpret the results. Successful students will have participated in the team work and will have gained an appreciation of how to collaborate in planning the project overall and how to plan their own contributions. Successful students will demonstrate the ability to design and present a poster paper suitable for a scientific conference. Successful students will demonstrate the ability to communicate scientific findings and results in writing for a non-expert readership. Successful students will demonstrate the ability to communicate orally scientific findings and results to an audience of scientific peers.	Astrophysics Group Project and Science Communication - ISP - PHY-30006
A successful student will be familiar with cosmological observations and be able to apply basic physics principles to the universe as a whole. A successful student will be able to calculate conditions in the universe at different times and use mathematics to relate the theory with the observations.	Cosmology - PHY-30001

Subject Knowledge and Understanding	
Learning Outcome	**Module in which this is delivered**
Knowledge of the contents of the ISM. Understand and appreciate the impact of stars on the ISM. Carry out quantitative calculations to support the above How the above is determined, observationally and by the application of basic Physics Understand the interaction between different components of this ISM	The Physics of Interstellar Medium - PHY-30002
Successful students will be able to demonstrate that they understand the properties of degenerate matter and that they appreciate the difference between normal and compact stars. They will understand how microscopic physical laws can be applied to macroscopic systems. They will understand how the structures of compact stars are determined and be aware of the importance of an accurate equation of state. They will appreciate how observations of compact stars can be used to probe physical laws at very high densities and be aware of the most recent research on the subject.	The Physics of Compact Objects - PHY-30003
The ability to apply quantitative techniques of quantum mechanics to straightforward problems in atomic and molecular physics. A detailed understanding the quantum behaviour of atoms in external electric and magnetic fields. The ability to solve a range of time-dependent quantum mechanical problems. The ability to understand aspects of atomic and molecular spectroscopy in a semi-quantitative fashion. An understanding of the nature of molecular wave- functions. An understanding of the links between classical and quantum physics.	Quantum Physics of Atoms and Molecules - PHY-30009
An understanding of the structure of polymer molecules and the application of physical characterisation techniques. An understanding of crystallinity and molecular orientation in polymer materials; application of physical techniques to determine the crystallinity and molecular orientation in polymer materials. An understanding of macrostructure in polymer materials; application of small angle x-ray scattering (SAXS) techniques to probe macrostructure in polymer materials. An understanding of microstructure in polymer materials; application of wide-angle x-ray scattering (WAXS) techniques to probe microstructure in polymer materials. An understanding of mechanical properties of polymer materials and their yield behaviour.	Polymer Physics - PHY-30010
Successful students will be able to demonstrate the ability to gather and critically assess information on their chosen advanced research topic in Astrophysics, and present this to a peer group by an oral presentation. Successful students will be able to assemble and review information on their chosen topic and produce a substantial, detailed dissertation. Successful students will be able to explain and communicate the subject matter of their chosen topic to a peer group by a poster presentation.	Dissertation

Subject Knowledge and Understanding	
Learning Outcome	**Module in which this is delivered**
Detail the ingredients and physical structure of the Standard Model; analyse the relativistic dynamics of particles in interactions and of particle beams in accelerators; compare and contrast the operation, design and relative advantages of different types of particle accelerator; describe and calculate key phenomena in lepton physics; explain and apply the quark model to classify hadrons and account quantitatively for their measured properties; understand and apply some of the key ideas and empirical foundations of quantum field theories for the fundamental forces.	Particle Physics and Accelerators - PHY-30033
Successful students will: Demonstrate a systematic understanding and detailed knowledge of the physics of binary stars and extrasolar planets, their evolution and interactions. Have acquired coherent and detailed knowledge of the methods used to discover and characterise of extrasolar planets and some knowledge of recent developments as the forefront of these subjects. Be able to apply established techniques of analysis to data from primary sources for eclipsing extrasolar planets and binary stars. To make judgements regarding the quality of the data and the limits of the information that can be extracted from the data.	Binary Stars and Extrasolar Planets - PHY-30024
Students will have acquired: Systematic understanding of the physical processes that govern the formation and evolution of planets, planetary atmospheres and Life. Coherent and detailed knowledge of the possibilities and limitations of searches for extra-solar planets and extra-terrestrial Life. Skills to exercise initiative in designing and executing an experiment, and to communicate ideas related to the experiment's context and objective. Be able to critically evaluate the possibilities and limitations of interstellar travel and communication.	Life in the Universe - PHY-30025
Has systematic understanding of the principles behind a variety of computational and numerical techniques that are commonly used in physical and astrophysical research. Students will acquire the knowledge to identify the appropriateness of computational and numerical approaches in a variety of situations and able to deploy them appropriately. To acquire skills in using a high-level computational language to implement and apply numerical techniques to physical and astrophysical problems. To demonstrate the ability to communicate the results of numerical calculations in written and graphical formats.	Computational Methods in Physics and Astrophysics - PHY-30026
Has systematic understanding of statistical techniques used to analyse and interpret physical/astrophysical data. Has conceptual understanding that enables the student to solve data analysis problems and to interpret scientific data, using statistical ideas and modern analysis techniques. Can critically evaluate data from primary sources to make and communicate judgements by applying established numerical analysis techniques to physical/astrophysical data.	Data Analysis and Model Testing - PHY-30027

Subject Knowledge and Understanding	
Learning Outcome	**Module in which this is delivered**
Describe and apply standard approximation techniques used in quantum mechanics. Describe the main concepts and results in a recent peer-reviewed journal article the application or interpretation of quantum physics. Analyse the rotation-vibration spectrum or Raman spectrum of a diatomic molecule. Describe and explain phenomena such as quantum entanglement and quantum teleportation. Discuss the merits of and problems with different proposed interpretations of quantum mechanics in the light of experimental results. Describe applications of quantum mechanics such as quantum dots and quantum cryptography and quantum computing. Interpret and apply Dirac bra-ket notation. Calculate the results of simple physical processes involving electrons using Pauli spin matrices.	Quantum Mechanics II - PHY-30029
Understand the basic principles and laws governing the physics of fluids (e.g. momentum/Euler equations) Apply the laws of fluid dynamics to specific topics found in nature and space (e.g. tsunamis) Use computer programs to solve basic problems in fluid dynamics Manipulate the equations of fluid dynamics in an applied context and numerically solve related problems Analyse and interpret complex processes like convection in the framework of fluid dynamics theory, making reasonable approximations	Physics of Fluids - PHY-30030
Describe quantitatively the structure and dynamics of atmospheres. Use the principles of thermodynamics to determine the structure of atmospheres. Solve the equation of radiative transfer to evaluate the effect of radiation on atmospheric structure. Apply the laws of motion to describe atmospheric dynamics and waves.	Atmospheric Physics - PHY-30031
Describe the properties of a plasma, in both Physics and Astrophysics contexts. Use electromagnetic theory to describe quantitatively the motion of charged particles. Use electromagnetic theory to describe quantitatively the propagation of an electromagnetic wave through a magnetised and unmagnetised plasma. Describe the nature and origin of electromagnetic and other waves that propagate in a plasma. Describe how the properties of a plasma, both natural and artificial, are determined, using techniques such as spectroscopy. Describe how plasmas arise, in both natural and artificial contexts.	Plasma Physics - PHY-30032

Subject Knowledge and Understanding	
Learning Outcome	**Module in which this is delivered**
Successful students will have gained an understanding of the central role played by the theory of electromagnetism in describing the universe and the world around them and be able to tackle problems and calculations in electromagnetism at a level appropriate to a final year honours degree course. Successful students will demonstrate the ability to work with and analyse astrophysical data and interpret the results. Successful students will have participated in the teamwork and will have gained an appreciation of how to collaborate in planning the project overall and how to plan their own contributions. Successful students will demonstrate the ability to design and present a poster paper suitable for a scientific conference. Successful students will demonstrate the ability to communicate scientific findings and results in writing for a non-expert readership. Successful students will demonstrate the ability to communicate orally scientific findings and results to an audience of scientific peers.	Combined Honours Students in Astrophysics will be taking two core modules. These are Electromagnetism and "Group Project and Science Communication". In addition to this, successful students will gain learning outcomes from two optional core modules of their own choice. Learning outcomes of these optional modules are at the beginning of this table.
Successful students will have gained an understanding of the central role played by the theory of electromagnetism in describing the universe and the world around them and be able to tackle problems and calculations in electromagnetism at a level appropriate to a final year honours degree course. Successful students will demonstrate the ability to work with and analyse astrophysical data and interpret the results. Successful students will have participated in the teamwork and will have gained an appreciation of how to collaborate in planning the project overall and how to plan their own contributions. Successful students will demonstrate the ability to design and present a poster paper suitable for a scientific conference. Successful students will demonstrate the ability to communicate scientific findings and results in writing for a non-expert readership. Successful students will demonstrate the ability to communicate orally scientific findings and results to an audience of scientific peers. Successful students will be able to demonstrate the ability to gather and critically assess information on their chosen advanced research topic in Astrophysics, and present this to a peer group by an oral presentation. Successful students will be able to assemble and review information on their chosen topic and produce a substantial, detailed dissertation. Successful students will be able to explain and communicate the subject matter of their chosen topic to a peer group by a poster presentation.	Combined Honours Students specialising in Astrophysics will be taking three core modules. These are Electromagnetism, "Group Project and Science Communication" and Dissertation. In addition to this, successful students will gain learning outcomes from five optional core modules of their own choice. Learning outcomes of these optional modules are at the beginning of this table.

Subject Knowledge and Understanding	
Learning Outcome	**Module in which this is delivered**
Apply the theory of General Relativity to solve problems in solar system, stellar and black hole astrophysics, identifying the appropriate analytical or numerical tools; quantitatively assess when a General Relativistic, rather than Newtonian approach is required; Describe and explain the main planks of evidence for General Relativity and for the existence of black holes; Use General Relativity to explain the existence, propagation and generation of gravitational waves and to solve problems relating to gravitational wave sources using appropriate analytical and numerical techniques; Explain the physical nature and purpose of the design and main components of gravitational wave detectors and quantitatively describe the factors that influence detector design and sensitivity; Engage with, and assimilate knowledge from, original research material and the primary literature.	General Relativity, Black Holes and Gravitational Waves - PHY-30035

Subject Specific Skills	
Learning Outcome	**Module in which this is delivered**
The ability to work safely in a laboratory and to have a knowledge and awareness of standard safety procedures. A sound familiarity with laboratory apparatus and techniques. Competent use of appropriate IT packages/systems for the analysis of data and the retrieval of information. An ability in numerical manipulation and estimation and the ability to present and interpret information graphically. An ability to use mathematical techniques and analysis to model physical behaviour. An ability to record and communicate scientific information, in particular through clear and accurate scientific reports. An ability to question, learn and assimilate knowledge and to evolve your views of the world in response to that new knowledge. An ability to contribute through research to the development of knowledge in Astrophysics.	Astrophysics Group Project and Science Communication - ISP - PHY-30006 Dissertation
Competent use of appropriate IT packages/systems for the analysis of data and the retrieval of information. An ability in numerical manipulation and estimation and the ability to present and interpret information graphically. An ability to use mathematical techniques and analysis to model physical behaviour. An ability to record and communicate scientific information, in particular through clear and accurate scientific reports. An ability to question, learn and assimilate knowledge and to evolve your views of the world in response to that new knowledge. An ability to contribute through research to the development of knowledge in Astrophysics.	All lecture modules

Key or Transferable Skills (graduate attributes)	
Learning Outcome	**Module in which this is delivered**
The ability to manage your own learning and to make appropriate use of text books, research-based materials and other learning resources. The ability to find information and make responsible use of it. The ability to listen. The ability to make effective written and oral presentations. The ability to work with numerical data. The ability to make sensible estimates. An awareness of the costs and benefits of your actions the ability to work effectively with a variety of types of Information Technology. The ability to plan, manage, execute and report an investigation. The ability to learn and gain understanding. The ability to work effectively both as an individual and as part of a team. The ability to sustain motivation for an extended period. A recognition of your responsibilities as an individual and as part of a team, an organisation.	All modules

9. Final and intermediate awards

Credits required for each level of academic award are as follows:

Honours Degree	360 credits	You will require at least 120 credits at levels 4, 5 and 6 You must accumulate a minimum of 135 credits in each Principal Subject (270 credits in total), with at least 45 credits at each level of study (Levels 4, 5 and 6) in each of two Principal Subjects (90 credits per year). Your degree title will be 'subject X and subject Y'. If you choose to study one Principal subject in your final year of study a minimum of 90 credits in that subject is required. Your degree title will be 'subject X with subject Y'.
Diploma in Higher Education	240 credits	You will require at least 120 credits at level 4 or higher and at least 120 credits at level 5 or higher
Certificate in Higher Education	120 credits	You will require at least 120 credits at level 4 or higher

International Year option: in addition to the above students must pass a module covering the international year in order to graduate with a named degree including the 'international year' wording. Students who do not complete, or fail the international year, will be transferred to the three-year version of the programme.

10. How is the Programme Assessed?

The wide variety of assessment methods used on this programme at Keele reflects the broad range of knowledge and skills that are developed as you progress through the degree programme. Teaching staff pay particular attention to specifying clear assessment criteria and providing timely, regular and constructive feedback that helps to clarify things you did not understand and helps you to improve your performance. The following list is representative of the variety of assessment methods used on your programme:

- **End of module examinations** test the ability of the student to describe, explain, and critically discuss the principles of the subject and to demonstrate competence in applying these principles to applications and to solve problems from appropriate areas of the discipline
- **Assessed Problem Sheets** assess the student's skills in solving numerical and other problems within the discipline by drawing on their scientific understanding and knowledge, and experience of experimental techniques
- **Laboratory and Project Reports** - structured proformas and full lab reports are formal summaries of work carried out in the laboratory and test students' understanding of the practical aspects of the programme and develop the skills necessary to enable students to present and analyse their results
- **Observation of laboratory skills and laboratory notebooks:** Throughout the extensive laboratory and other practical work in this programme, many types of assessment are utilised to achieve the learning outcomes. Notebooks are used to communicate the results of work accurately and reliably and to encourage good working practice, including managing risk assessments and following safe working practices
- **Oral and/or Poster presentations on project work** demonstrate the ability of the student to present complex concepts and information in a clear and concise manner, to interact and communicate effectively to a wide range of professional environments, including to both scientific and non-scientific audiences
- **In-class exercises and tests** taken either conventionally or online via the Keele Learning Environment (KLE) assess students' subject knowledge and their ability to apply it in a more structured and focused way
- **Individual or group oral presentations** assess individual student's subject knowledge and understanding. They also test their ability to work effectively as members of a team, to communicate what they know orally and visually, and to reflect on these processes as part of their own personal development

Marks are awarded for summative assessments designed to assess your achievement of learning outcomes. You will also be assessed formatively to enable you to monitor your own progress and to assist staff in identifying and addressing any specific learning needs. Feedback, including guidance on how you can improve the quality of your work, is also provided on all summative assessments within three working weeks of submission, unless there are compelling circumstances that make this impossible, and more informally in the course of tutorial and seminar discussions.

11. Contact Time and Expected Workload

This contact time measure is intended to provide you with an indication of the type of activity you are likely to undertake during this programme. The data is compiled based on module choices and learning patterns of students on similar programmes in previous years. Every effort is made to ensure this data is a realistic representation of what you are likely to experience, but changes to programmes, teaching methods and assessment methods mean this data is representative and not specific.

Undergraduate courses at Keele contain an element of module choice; therefore, individual students will experience a different mix of contact time and assessment types dependent upon their own individual choice of modules. The figures below are an example of activities that a student may expect on your chosen course by year stage of study. Contact time includes scheduled activities such as: lecture, seminar, tutorial, project supervision, demonstration, practical classes and labs, supervised time in labs/workshop, fieldwork and external visits. The figures are based on 1,200 hours of student effort each year for full-time students.

Activity

	Scheduled learning and teaching activities	**Guided independent Study**	**Placements**
Year 1 (Level 4)	39%	61%	0%
Year 2 (Level 5)	37%	63%	0%
Year 3 (Level 6)	29%	71%	0%

12. Accreditation

This subject/programme is accredited by: The Institute of Physics (IoP).

Please note the following:

- Graduates with accredited BSc degrees are eligible for Associate Membership of the IoP. After a period of relevant post-degree experience and professional development they may apply for full membership of the IoP and for Chartered Physicist status.

13. University Regulations

The University Regulations form the framework for learning, teaching and assessment and other aspects of the student experience. Further information about the University Regulations can be found at: http://www.keele.ac.uk/student-agreement/

A student who has completed a semester abroad will not normally be eligible to transfer onto the International Year option.

14. What are the typical admission requirements for the Programme?

See the relevant course page on the website for the admission requirements relevant to this programme: https://www.keele.ac.uk/study/

Applicants who are not currently undertaking any formal study or who have been out of formal education for more than 3 years and are not qualified to A-level or BTEC standard may be offered entry to the University's Foundation Year Programme.

Applicants for whom English is not a first language must provide evidence of a recognised qualification in English language. The minimum score for entry to the Programme is Academic IELTS 6.0 or equivalent.

English for Academic Purposes

Please note: All new international students entering the university will sit a diagnostic language assessment. Using this assessment, the Language Centre may allocate you to an English language module which will become compulsory. This will replace any GCP modules. *NB:* students can take an EAP module only with the approval of the English Language Programme Director and are not able to take any other Language modules in the same academic year.

English Language Modules at Level 4:

- Business - ENL-90003 Academic English for Business Students (Part 1); ENL-90004 Academic English for Business Students (2)
- Science - ENL-90013 Academic English for Science Students
- General - ENL-90006 English for Academic Purposes 2; ENL-90001 English for Academic Purposes 3; ENL-90002 English for Academic Purposes 4

Recognition of Prior Learning (RPL) is considered on a case-by-case basis and those interested should contact the Programme Director. The University's guidelines on this can be found here: http://www.keele.ac.uk/qa/accreditationofpriorlearning/

15. How are students supported on the programme?

All the Astrophysics modules are supported by learning materials that are accessible to students via the KLE athttps://students.keele.ac.uk/webapps/login/.

Academic Mentor

All students are assigned an Academic Mentor as a part of University's Academic Mentor system for your duration of studies at Keele. There is a formal requirement for the Academic Mentors to meet with first year mentees during the first week of the semester one. Subsequently, Academic Mentors should meet at least four times per year to discuss progress and offer support and advice. During the subsequent undergraduate years Academic Mentors should meet at least three times per year. Students can make arrangement to seek help or advice on any matter that affects your life and work as a student at Keele.

More details available at: https://www.keele.ac.uk/students/academiclife/academicmentoring/

Year Tutor

Each year of study has an associated Year Tutor who monitors the students and the modules to ensure the course is running smoothly and that you are making progress as you should. They will note any problems and bring them to the attention of the Course Management Committee who will decide on an appropriate course of action. You should regard the year tutor as your first point of contact to discuss any topic related to the courses or your own academic performance.

Student with disabilities

If you have long-term disabilities, you will have the assistance of the Disability Coordinator and the Examinations Office and from academic and support staff who liaise with these services.

Health and Safety

All the students are briefed on the health and safety as part of their induction and repeated again at the beginning of the first laboratory session. Students are required to sign an agreement that they have read the Safety Handbook, and that they will abide by the rules and regulations governing the safety and welfare of all members within the University. The Safety handbook can be accessed on the KLE (https://students.keele.ac.uk/) under the section "Physics and Astrophysics Information"

Further information

It is essential that students check the KLE (http://students.keele.ac.uk/) for up to date information on course and teaching materials related to their Astrophysics modules.

16. Learning Resources

The Physics and Astrophysics section of the School is housed in Lennard Jones Building, which contains well-equipped undergraduate Astrophysics teaching laboratories and a dedicated PC laboratory supporting both Windows and Linux. There are rooms available in the building for the students to work and socialise with their peers. There are dedicated boxes located in the building for submission of the problem sheets and laboratory reports. In addition, the School Office is open continuously during the week from 9 am to 5 pm to answer student queries

17. Other Learning Opportunities

Study abroad (semester)

Students on the programme have the potential opportunity to spend a semester abroad in their second year studying at one of Keele's international partner universities.

Exactly which countries are available depends on the student's choice of degree subjects. An indicative list of countries is on the website (http://www.keele.ac.uk/studyabroad/partneruniversities/); however this does not guarantee the availability of study in a specific country as this is subject to the University's application process for studying abroad.

No additional tuition fees are payable for a single semester studying abroad but students do have to bear the costs of travelling to and from their destination university, accommodation, food and personal costs. Depending on the destination they are studying at additional costs may include visas, study permits, residence permits, and compulsory health checks. Students should expect the total costs of studying abroad to be greater than if they study in the UK, information is made available from the Global Education Team throughout the process, as costs will vary depending on destination.

Whilst students are studying abroad any Student Finance eligibility will continue, where applicable students may be eligible for specific travel or disability grants. Students who meet external eligibility criteria may be eligible for grants as part of this programme. Students studying outside of this programme may be eligible for income dependent bursaries at Keele. Students travel on a comprehensive Keele University insurance plan, for which there are currently no additional charges. Some governments and/or universities require additional compulsory health coverage plans; costs for this will be advised during the application process.

Study Abroad (International Year)

A summary of the International Year, which is a potential option for students after completion of year 2 (Level 5), is provided in the Annex for the International Year.

Other opportunities

Also there are other opportunities such as Physics Ambassador Scheme and e-mentoring scheme for students to enhance their employability skills.

18. Additional Costs

As to be expected there will be additional costs for inter-library loans and potential overdue library fines,

print and graduation. We do not anticipate any further costs for this programme.

19. Quality management and enhancement

The quality and standards of learning in this programme are subject to a continuous process of monitoring, review and enhancement.

- The School Education Committee is responsible for reviewing and monitoring quality management and enhancement procedures and activities across the School.
- Individual modules and the programme as a whole are reviewed and enhanced every year in the annual programme review which takes place at the end of the academic year.
- The programmes are run in accordance with the University's Quality Assurance procedures and are subject to periodic reviews under the Revalidation process.

Student evaluation of, and feedback on, the quality of learning on every module takes place every year using a variety of different methods:

- The results of student evaluations of all modules are reported to module leaders and reviewed by the Programme Committee as part of annual programme review.
- Findings related to the programme from the annual National Student Survey (NSS), and from regular surveys of the student experience conducted by the University, are subjected to careful analysis and a planned response at programme and School level.
- Feedback received from representatives of students in all three years of the programme is considered and acted on at regular meetings of the Student Staff Voice Committee.

The University appoints senior members of academic staff from other universities to act as external examiners on all programmes. They are responsible for:

- Approving examination questions
- Confirming all marks which contribute to a student's degree
- Reviewing and giving advice on the structure and content of the programme and assessment procedures

Information about current external examiner(s) can be found here:
http://www.keele.ac.uk/qa/externalexaminers/currentexternalexaminers/

20. The principles of programme design

The programme described in this document has been drawn up with reference to, and in accordance with the guidance set out in, the following documents:

a. UK Quality Code for Higher Education, Quality Assurance Agency for Higher Education: http://www.qaa.ac.uk/quality-code
b. QAA Subject Benchmark Statement: Physics, Astronomy and Astrophysics (2019) - https://www.qaa.ac.uk/docs/qaa/subject-benchmark-statements/subject-benchmark-statement-physics-astronomy-and-astrophysics.pdf?sfvrsn=eff3c881_4
c. Keele University Regulations and Guidance for Students and Staff: http://www.keele.ac.uk/regulations
d. The Institute of Physics Accreditation Scheme for First Degree Courses in Physics - Degree accreditation and recognition | Institute of Physics (iop.org)

21. Annex - International Year

Astrophysics with International Year

Please note: in order to be eligible to take the International Year option your other subject must also offer this option. Please refer to the information published in the course document for your other subject.

International Year Programme

Students registered for this Combined Honours programme may either be admitted for or apply to transfer during their period of study at Level 5 to the Combined Honours programme in both their principal subjects, providing that they meet the progression criteria outlined in this document. Students accepted onto the International Year programme will have an extra year of study at an international partner institution after they have completed Year 2 (Level 5) at Keele.

Students who successfully complete both the second year (Level 5) and the International Year will be permitted to progress to Level 6. Students who fail to satisfy the examiners in respect of the International Year will normally revert to the Combined Honours programme without the International Year and progress to Level 6 on that basis. The failure will be recorded on the student's final transcript.

Study at Level 4, Level 5 and Level 6 will be as per the main body of this document. The additional detail contained in this annex will pertain solely to students registered for the International Year option.

International Year Programme Aims

In addition to the programme aims specified in the main body of this document, the international year programme of study aims to provide students with:

1. Personal development as a student and a researcher with an appreciation of the international dimension of their subject
2. Experience of a different culture, academically, professionally and socially

Entry Requirements for the International Year

Students may apply to the 4-year programme during Level 5. Admission to the International Year is subject to successful application, interview and references from appropriate staff.

The criteria to be applied are:

- Academic Performance (an average of 55% across all modules in Semester 1 at Level 5 is normally required. Places on the International Year are then conditional on achieving an average mark of 55% across all Level 5 modules. Students with up to 15 credits of re-assessment who meet the 55% requirement may progress to the International Year. Where no Semester 1 marks have been awarded performance in 1st year marks and ongoing 2nd year assessments are taken into account)
- General Aptitude (to be demonstrated by application for study abroad, interview during the 2nd semester of year 2 (Level 5), and by recommendation of the student's Academic Mentor, 1st and 2nd year tutors and programme director)

Students may not register for both an International Year and a Placement Year.

Student Support

Students will be supported whilst on the International Year via the following methods:

- Phone or Skype conversations with Study Abroad tutors, in line with recommended Academic Mentoring meeting points.
- Support from the University's Global Education Team

Learning Outcomes

In addition to the learning outcomes specified in the main text of the Programme Specification, students who complete a Keele undergraduate programme with International Year will be able to:

1. Describe, discuss and reflect upon the cultural and international differences and similarities of different learning environments
2. Discuss the benefits and challenges of global citizenship and internationalisation
3. Explain how their perspective on their academic discipline has been influenced by locating it within an international setting.
4. Engage effectively in academic and scientific discourse in an international setting;
5. Integrate, apply and develop fundamental physical principles to describe and explain phenomena and solve problems within the context of specialised areas of Astrophysics and/or Physics.

Please note that students on Combined Honours programmes with International Year must meet the subject-specific learning outcomes for BOTH their principal subjects.

These learning outcomes will all be assessed by the submission of a satisfactory individual learning agreement, the successful completion of assessments at the partner institution and the submission of the reflective portfolio element of the international year module.

Course Regulations

Students registered for the International Year are subject to the programme-specific regulations (if any) and the University regulations. In addition, during the International Year, the following regulations will apply:

Students undertaking the International Year must complete 120 credits, which must comprise *at least 40%* in the student's discipline area.

This may impact on your choice of modules to study, for example you will have to choose certain modules to ensure you have the discipline specific credits required.

Students are barred from studying any module with significant overlap to the Level 6 modules to be studied on their return. Significant overlap with Level 5 modules previously studied should also be avoided.

Additional costs for the International Year

Tuition fees for students on the International Year will be charged at 15% of the annual tuition fees for that year of study, as set out in Section 1. The International Year can be included in your Student Finance allocation, to find out more about your personal eligibility see: www.gov.uk

Students will have to bear the costs of travelling to and from their destination university, accommodation, food and personal costs. Depending on the destination they are studying at additional costs may include visas, study permits, residence permits, and compulsory health checks. Students should expect the total costs of studying abroad be greater than if they study in the UK, information is made available from the Global Education Team throughout the process, as costs will vary depending on destination.

Students who meet external eligibility criteria may be eligible for grants as part of this programme. Students studying outside of this programme may be eligible income dependent bursaries at Keele.

Students travel on a comprehensive Keele University insurance plan, for which there are currently no additional charges. Some Governments and/or universities require additional compulsory health coverage plans; costs for this will be advised during the application process.

Version History

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Previous documents

Version No	Year	Owner	Date Approved	Summary of and rationale for changes
1	2022/23	ARUMUGAM MAHENDRASINGAM	09 June 2022	
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