University of Hertfordshire UH

Module Catalogue

School of Physics, Engineering and Computer Science

Department of Physics, Astronomy and Mathematics

A DIRECTORY OF UNDERGRADUATE MODULES FOR EXCHANGE AND STUDY ABROAD STUDENTS

SEMESTER A, B AND AB 2023/24

List of Modules

Semester A (15-credit modules)

Level 4

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Module code: 4PAM1068

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Module name: Mathematical Methods

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Module name: Numbers and Sets

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Module name: Principles of Data Science

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Level 5

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Module code: 5PAM1044

Module name: Physics of the Solar System

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Level 4

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Level 5

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Level 6

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Module name: Multivariate Statistics

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Semester A&B (30-credit modules)

Level 4

Module name: The Physical Universe

Module code: 4PAM1013

Module name: Special Relativity and Quantum Physics

Module code: 4PAM1066

Level 6

Module name: Financial Mathematics & Derivative Pricing

Module code: 6PAM1031

Module name: Physics Project and Investigative Skills

Module code: 6PAM1052

Module name: Astrophysics Project and Investigative Skills

Module code: 6PAM1054

Module name: Mathematical Project and Investigative Skills

Module code: 6PAM2010

INTRODUCTION

This module directory is specifically designed for exchange students to select modules at the School of Physics, Engineering and Computer Science (SPECS), the Department of Physics, Astronomy and Mathematics (PAM), University of Hertfordshire.

1. Please see the box below explaining the module codes:

4PAM1034		
4	**PAM**	**1034**
Module level	School of study	Module code

2. As an exchange student you can choose modules from levels 5, 6 and exceptionally at level 4.

Level 4	**Level 5**	**Level 6**
First Year module	Second year module	Third Year module

3. Co-requisites, pre-requisites and prohibited combinations.

Some of the modules may have co-requisites or pre-requisites which you will find indicated in each module. Please note for you, as an exchange student, *if a module has co-requisites or pre-requisites you must have previously studied the subject and have completed the relevant module(s) at your home institution.* When sending your application, please include a copy of your transcript to show that you have taken the minimum required co-requisites or pre-requisites module(s) at your home institution. Additionally, we may require you to provide a module description in order to evidence prior study.

If you are in the process of completing the required module(s) at the time of the application and you do not have the final copy of the transcript, please include a letter from your home institution clearly listing the modules that you are registered on.

Prohibited combinations- please note if there are modules listed under prohibited combinations you can only study one of the modules.

Module name: The Physical Universe

Module code: 4PAM1013 Semester: AB Credits: 30

Module Aims:

The aims of this module are to enable students to learn and apply concepts, principles and nomenclature underpinning physics and astrophysics. It also aims to develop skills in observation, measurement and interpretation.

Intended Learning Outcomes:

Successful students will typically:

- be able to explain and apply physical laws in mechanics and gravity, waves and optics, thermodynamics and the structure of matter;
- be able to describe and explain the broad structure and evolution of the universe and the physical nature of planets, stars and galaxies.

Successful students will typically:

- be able to express and solve problems in classical physics and astrophysics, in clear mathematical terms;
- be able to apply laboratory/observatory skills to the study of physical/celestial phenomena;
- be able to implement practical activities as part of small group;
- be able to implement independent background research and communicate their findings;
- be able to follow good ethical practice (avoiding collusion and plagiarism) when working.

Module Content:

The Physical Universe ensures that students establish or refine their knowledge and skills in core areas of classical physics, while receiving an introduction to a range of topics in astrophysics. It will provide a broad survey of the universe and the structure of matter, and will show how physics and mathematics are used as theoretical tools to interpret data collected at telescopes.

In this module you will develop your skills in research enquiry and problem solving, analysis and evaluation, team and organisational working, interpersonal and communication skills, scientific writing and information searching.

Pre and Co requisites:

None

Total hours: 300

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Special Relativity and Quantum Physics

Module code: 4PAM1066 Semester: AB Credits: 30

Module Aims:

The aims of this module are to enable students to appreciate the significance of the major developments in physics during the 20th century and to understand, at an introductory level, the modern physical concepts underlying special relativity and quantum physics. It also aims to teach students to apply their knowledge to solve problems in non−classical physics and to reinforce their understanding through a range of classroom, laboratory and independent study activities.The aims of this module are to enable students to learn and apply concepts, principles and nomenclature underpinning physics and astrophysics. It also aims to develop skills in observation, measurement and interpretation.

Intended Learning Outcomes:

Successful students will typically:

- be able to understand the basic concepts and theoretical models in modern physics including relativistic effects such as time dilation, relativistic mass, matter waves, particle−wave duality, quantization of energy and angular momentum, the quantum model of the atom, spectra, the structure and properties of nuclei, radioactivity and molecules;
- be able to recognise the importance of the experimental evidence underpinning the development of these concepts;
- be able to appreciate the importance of clarity of argument, precision, justification of method, and use of units, when solving numerical problems;
- be able to develop a strong introductory grasp of the topics enabling further study at a more advanced level.

Successful students will typically:

- be able to analyse the behaviour of simple physical systems undergoing relativistic motion and predict the properties of simple quantum systems such as a particle in a box, single electron atoms, diatomic molecules and nuclei;
- be able to apply their knowledge to solve numerical problems;
- be able to carry out, analyse and report on important experiments involving the physical concepts taught in the course;
- be able to work effectively as part of a small team when in the Laboratory, organising their activities and communicating efficiently;
- be able to engage confidently with the material both in classroom and independent study activities.

Module Content:

The module provides an introduction to some of the most important and exciting concepts in 20th Century physics: it introduces the theories of special relativity and quantum mechanics, energy and radiation, wave particle duality, and applies these ideas to atomic, nuclear and molecular physics. It will provide a foundation for more advanced treatments of these subjects. The course content is delivered in the form of lectures, tutorial/problem sessions and laboratory classes. Students are expected to develop strong study skills such as note−taking and study planning, and work independently as well as in groups.

In this module you will develop your skills in problem solving and research enquiry, analysis and evaluation, team and organisational working, and interpersonal skills.

Pre and Co requisites:

None

Total hours: 300

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Experimental Physics

Module code: 4PAM1068 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to develop the experimental skills of a physicist, using a mixture of workshops and assessed laboratory sessions to teach the experimental method including correct use of equipment, report writing and working in teams. It is also an aim to put particular emphasis on the correct statistical treatment of errors including full error propagation.

Intended Learning Outcomes:

Successful students will typically:

- develop a knowledge of the experimental process in physics;
- be able to explain the concepts of error analysis.

Successful students will typically:

- be able to carry out teamwork in small groups;
- be able to produce written scientific reports;
- be able to use a variety of scientific instruments;
- be able to record and analyse experimental data;
- be able to critically evaluate laboratory investigations.

Module Content:

The module consists of experimental investigations into various physical phenomena such as classical mechanics, thermodynamics, waves and optics, fluids, electromagnetism and atomic spectra. It also introduces the basic techniques of laboratory practice, including data recording, uncertainty estimation, data and uncertainty analysis, maintaining a log book and writing reports. The module develops skills in research enquiry and problem solving, analysis and evaluation, organisational working, interpersonal and communication skills, scientific writing and information searching.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Introduction to Mathematical Reasoning

Module code: 4PAM2004 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students transitioning to university-level mathematics to learn to think about maths in a different way from what they may have done at school. It also aims to engage students with abstract maths in the manner that will be required in further study, career and beyond.

Intended Learning Outcomes:

Successful students will typically:

- be able to recognise, and appreciate the importance of, precise definitions and sound arguments;
- be able to demonstrate understanding of how advanced mathematics is written.

Successful students will typically:

- be able to parse, criticise and improve mathematical writing;
- be able to express ideas and logical chains of thought clearly in written form;
- be able to develop and demonstrate digital, organisational and study skills needed in academia and beyond.

Module Content:

This module equips students with both the practical and conceptual tools to successfully study mathematics at university.
On the practical side, students will learn key digital skills including how to use software to write technical documents and how to access, search, and reference online resources.
Just as importantly, on the conceptual side, students will learn what makes university mathematics different from its school counterpart: a focus on critical thinking, accurate reasoning, and clear communication of ideas in written form.
These skills are vital not only for academic mathematics, but also across the spectrum of real-world graduate-level careers.
Material for discussion will be drawn from diverse sources, including e.g. YouTube videos. The focus here is less on learning specific mathematical material and more on learning how to approach new material as a mathematician.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Mathematical Methods

Module code: 4PAM2006 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to standardise their knowledge of topics covered in different A-level school syllabi, and to be introduced to important mathematical topics at university level. It also aims to introduce students to various applications of mathematics.

Intended Learning Outcomes:

Successful students will typically:

- be able to explain important mathematical topics relating to hyperbolic functions, differential and integral calculus;
- be able to explain important mathematical topics relating to vectors and matrices, their eigenvalues and eigenvectors;
- be able to explain important mathematical concepts relating to complex numbers and the Argand diagram.

Successful students will typically:

- be able to apply differential calculus to functions of one or more variables, and integral calculus to functions of one variable;
- be able to manipulate vectors and matrices, solve systems of linear equations and determine eigenvalues and eigenvectors, and perform transformations between co-ordinate systems;
- be able to manipulate complex numbers, solve roots and powers of complex numbers and use the Argand diagram.

Module Content:

On entry to the degree students have a range of mathematical backgrounds and knowledge, and this module has been designed to standardise mathematical knowledge through the first semester of study. You will review core areas of A-level mathematics, which will be extended to enhance your knowledge. You will learn important and widely applicable mathematical techniques relating to hyperbolic functions, matrices, vectors, differential and integral calculus, and complex numbers. In this module you will develop your skills in mathematical problem solving, analysis and evaluation.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
70%	30%	0%

Module name: Probability and Statistics

Module code: 4PAM2008 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to perform standard probability calculations and employ a variety of basic statistical techniques to develop an elementary understanding of the principles underlying these techniques. Additionally, students will learn how make effective use of a statistical computer package.

Intended Learning Outcomes:

Successful students will typically:

- be able to demonstrate a knowledge and understanding of a range of probability theory, in the context of elementary statistical and probabilistic techniques;
- be able to demonstrate understanding of how to use a computer package for statistical analysis.

Successful students will typically:

- be able to apply a variety of basic statistical techniques to data;
- be able to determine the appropriate statistical method to use in a particular well-defined situation;
- be able to make appropriate use of a statistical computer package to manipulate and analyse data;
- be able to work effectively as a member of a group.

Module Content:

This is an introductory module in statistics and probability theory. Basic ideas such as initial data analysis, the mean, standard deviation and variance, probability, statistical distributions, the use of a statistical package, the use of data for inference and decision making are covered. This involves confidence intervals for means and techniques for hypothesis testing for differences between means, differences between proportions and for the size of a correlation.

Other topics covered include simple linear regression, and the analysis of category data and contingency tables.

A wide variety of situations in which these techniques may be employed will be considered, with examples taken from business, engineering, science, social sciences, etc. The emphasis throughout is on conceptual understanding and the development of practical statistical skills, supported by the use of a statistical computer package.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Numbers and Sets

Module code: 4PAM2010 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to formulate basic mathematical statements in precise language; to familiarise students to working with fundamental mathematical concepts such as logic, sets, binary relations, and functions; as well as to develop their mathematical reasoning skills and learn how to structure arguments and proofs.

Intended Learning Outcomes:

Successful students will typically:

- be able to demonstrate comprehension of mathematical statements involving sets, relations and functions written in standard technical notation;
- be able to demonstrate understanding of simple mathematical proofs and appreciate the need for precision and rigour in every step.

Successful students will typically:

- be able to formulate mathematical statements in precise language;
- be able to use correct notation and terminology when working with sets, relations, functions and logic;
- be able to write rigorous proofs of simple mathematical claims.

Module Content:

This module aims to present the fundamental ideas, language, and skills on which the rest of mathematics is based. The main distinction that mathematics holds over every other discipline is that, by using mathematics, we can prove our claims beyond doubt, interpretation, or debate. This is possible because mathematics, used correctly, is a precise language free from the vagueness and ambiguity of everyday discourse.

In this module, you will familiarise yourself with the use of technical mathematical language and gain the skills necessary to prove simple mathematical claims. In the process, you will re-encounter many familiar concepts such as numbers, sets, or functions and learn to view them as a mathematician does.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Financial and Actuarial Mathematics

Module code: 4PAM2012 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to learn the first principles of the mathematics used to analyse and value financial securities. Students will gain an understanding of the characteristics of the most common securities, and how they are traded on the financial markets. We will then develop techniques to calculate the price or value of a security so that an investor can make informed decisions when purchasing investments or can assess the performance of the investments they already own. We will also introduce the concept of investment risk and how to quantify it.

Intended Learning Outcomes:

Successful students will typically:

- be able to demonstrate knowledge of a range of financial products;
- be able to demonstrate understanding of how financial products are traded and priced;
- be able to identify the risks associated with financial products.

Successful students will typically:

- be able to use mathematical and actuarial techniques to value the cashflows relating to an investment and quantify the risks associated with it;
- be able to compare and assess different investment opportunities;
- be able to demonstrate an understanding of company data and draw simple conclusions from it.

Module Content:

The aim of this module is to introduce students to the fundamental concepts in financial mathematics. You will learn about the range of investments available and how these are traded on the markets. You will gain an understanding of how to analyse and value these investments by applying mathematical and actuarial techniques such as compound interest, rates of return, discounting and accumulating. You will use recognised criteria to compare alternative investment opportunities, gaining an understanding of how an investor can make informed decisions when purchasing investments or can assess the performance of investments they already own. You will also gain an understanding of the risks involved in investing in securities, including the sources of risk and methods to quantify and mitigate risk. To complement the theoretical concepts explored in lectures, you will have the opportunity to download live market data and analyse it.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Linear Algebra

Module code: 4PAM2014 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to solve linear systems and understand the concept of a basis of a vector space. It will also teach them how to orthogonalize vectors, and how to determine eigenvalues and eigenvectors of a matrix.

Intended Learning Outcomes:

Successful students will typically:

- be able to demonstrate understanding of orthogonalization using the Gram-Schmidt method;
- be able to demonstrate understanding of the properties of determinants.

Successful students will typically:

- be able to determine solutions of linear systems of the form Ax=b;
- be able to find a basis of a vector space;
- be able to determine the eigenvalues and eigenvectors of a matrix.

Module Content:

Linear algebra is a fundamental area of mathematics and is arguably the most powerful mathematical tool ever developed. It is a core topic of study with applications to fields as diverse as business, economics, engineering, science etc. It also has applications to our daily life: for an example of linear algebra at work, one needs to look no further than the Google search engine, which relies on linear algebra to rank the results of a search with respect to relevance. In this module you will learn basic concepts of linear algebra, including matrices, eigenvalues and eigenvectors, that provide the first step towards the understanding of how to use these tools in pure and applied mathematics.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Applications of Calculus

Module code: 4PAM2016 Semester: B Credits: 15

Module Aims:

The aims of this module are to extend students' knowledge and skills in important topics in calculus and to introduce students to various applications of mathematics.

Intended Learning Outcomes:

Successful students will typically:

- be able to explain important mathematical topics relating to improper integrals, ordinary differential equations, partial differentiation, power series, and Fourier series.

Successful students will typically:

- be able to recognise and solve improper integrals and find partial derivatives;
- be able to determine the interval of convergence of a power series;
- be able to find the Fourier series of a periodic function;
- be able to solve ordinary and differential equations using a variety of techniques;
- be able to communicate mathematical concepts in power series and ordinary differential equations.

Module Content:

This module will extend the mathematical knowledge gained in the module 'Mathematical Methods'. It will explore a variety of mathematical methods that use calculus. You will learn important and widely applicable mathematical techniques relating to improper integrals, differential equations, partial differentiation, power series, and Fourier series. In this module you will develop your skills in mathematical problem solving, analysis and evaluation.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
70%	30%	0%

Module name: Computational Modelling

Module code: 4PAM2018 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to understand and be able to write basic computer programs, and to use mathematical software in the support of Mathematics and the Physical Sciences.

Intended Learning Outcomes:

Successful students will typically:

- be able to demonstrate understanding of principles, usage and syntax of software packages for presenting and implementing mathematical/scientific calculations;
- be able to explain the constructs of a programming language.

Successful students will typically:

- be able to use a programming language to undertake scientific analysis;
- be able to solve mathematical/scientific problems and present their results using appropriate software packages.

Module Content:

In this module you will learn how to use a programming language. You will solve exercises during practical classes and independent study time. You will see how to develop scientific and mathematical models and how they can be implemented in a computational environment. Towards the end of the module, you will carry out a mini-project on mathematical computing, and present the results.

The module develops skills in problem solving, computer programming, analysis and evaluation, and interpersonal and communication skills.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Principles of Data Science

Module code: 4PAM2022 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to understand the steps required to take on a data science project, and use data intelligently and learn how to handle it with care. Additionally, students will develop an appreciation of their legal and ethical responsibilities as data scientists in their employment and in other relevant contexts.

Intended Learning Outcomes:

Successful students will typically:

- demonstrate knowledge and understanding of the legal and ethical standards from relevant professional bodies to which a data science professional is expected to adhere;
- demonstrate knowledge and understanding of the five most important steps of data science (asking the question obtaining data; exploring data; building and testing the model; communicating the results).

Successful students will typically:

- be able to distinguish between types of data (structured/unstructured; quantitative/qualitative) and different types of data structures, as well as their applications;
- be able to select the appropriate tools to interpret case studies;
- be able to critically assess the outputs of models.

Module Content:

The module is designed to provide students with the principles of planning, conducting, and critically reviewing data scientific research in applied contexts. By the end of the module, students will be confident with the language and conventions of data science, including types of data, data structures, and the necessary steps to perform a data science project, including the ethical and legal aspects.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: IT Literacy and Core Skills

Module code: 4PAM2023 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to understand fundamental concepts in IT, including operating systems, programming languages and networks. Additionally, students will develop skills in using multiple operating systems, including command−line interfaces and document preparation systems.

Intended Learning Outcomes:

Successful students will typically:

- demonstrate knowledge and understanding of MS Windows, Mac OS and Linux operating systems;
- demonstrate knowledge and understanding of different programming languages, both compiled and scripted;
- demonstrate knowledge and understanding of how data is stored and transferred in and between computers;
- demonstrate knowledge and understanding of the LaTeX document preparation system.

Successful students will typically:

- be able to confidently use different operating systems;
- be able to interact with the command line, including use of the Linux shell;
- be able to prepare documents using LaTeX.

Module Content:

The module is designed to provide students with basic literacy in the use of IT and confidence in interacting with computers running different operating systems. It will develop a broad understanding of how computers store and communicate data, and how computers can be programmed in different ways. It will also develop skills in using the LaTeX document preparation system and understanding of the principles by which computers are programmed.

By the end of the module students will be able to navigate different operating systems, interact with file systems using the command line, and be able to produce professional−quality typeset documents using LaTeX.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Data Science Laboratory 1

Module code: 4PAM2024 Semester: B Credits: 15

Module Aims:

As part of this module, students will develop practical skills for developing and deploying solutions to data science problems, including mastering simple data engineering techniques for data preparation, learning how to develop algorithms and models to solve a range of tasks, learning how to use a version control system for code development and establish 'good practice' in code development.

Intended Learning Outcomes:

Successful students will typically:

- Demonstrate knowledge and understanding of concepts of version control for code development;
- Demonstrate knowledge and understanding of key data manipulation techniques for data preparation;
- Demonstrate knowledge and understanding of how to approach a range of different data science problems to obtain an efficient solution.

Successful students will typically:

- Be able to maintain and develop code using the git version control system;
- Be able to apply different techniques for cleaning data and preparing it for analysis;
- Be able to design and implement algorithms for clustering, classification and regression problems;
- Be able to communicate their findings to others, including a critical assessment of performance.

Module Content:

This module is laboratory based, providing students with hands−on training in several techniques fundamental to data science. It also provides an environment where students have an opportunity to hone general coding skills, including good practice in software development. All students will create and maintain a git repository for their code and learn the principles of proper version control of software. Through a series of self−contained data science 'challenges' students will learn and put into practice (1) the key principles of data engineering, such as dealing with noisy and missing data, (2) design and implement algorithms and data analysis pipelines to tackle a variety of problems in the most efficient manner, and (3) critically analyse outputs and communicate findings to others.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Principles of Data Presentation

Module code: 4PAM2026 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to make use of the principles of data visualisation when analysing data and be able to communicate the outcomes clearly.

Intended Learning Outcomes:

Successful students will typically:

- Demonstrate knowledge and understanding of the underlying concepts and principles of data visualisation.

Successful students will typically:

- Be able to apply appropriate data visualisation techniques in the communication and presentation of results of data analysis;
- Be able to make use of appropriate software;
- Be able to demonstrate the skills needed to work and communicate in a group.

Module Content:

The module will begin with simple data presentation techniques such as graphical and numerical summaries and consider how these can be used to appropriately present data. The module will then develop these themes through the use of more advanced graphical summaries and data visualisation methods (including their production in a suitable statistical software package), the presentation of results in different media and the reporting of analyses (including the correct interpretation of results and discussion of modelling assumptions).

The module develops skills in problem solving, IT skills, analysis and evaluation, and interpersonal and communication skills.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Electromagnetism

Module code: 5PAM1044 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to gain knowledge about the nature of physical phenomena relating to electromagnetism, understand the laws of electric and magnetic fields, and the nature of Maxwell's Equations. It also aims to develop an understanding of electromagnetic wave propagation, and give experience in solving related analytical/numerical problems, and carrying out practical experiments on electromagnetism in the laboratory.

Intended Learning Outcomes:

Successful students will typically:

- be able to explain the laws of electric and magnetic fields;
- be able to derive how electromagnetism governs the behaviour of electric circuits involving inductors, resistors and capacitors;
- be able to explain the meaning of Maxwell's Equations (in integral and differential form) and demonstrate that electric and magnetic fields satisfy the wave equation.

Successful students will typically:

- be able to solve analytical/numerical problems in electromagnetism in a selection of topics;
- be able to demonstrate practical skills related to experiments on electromagnetism in the laboratory;
- be able to implement practical activities as part of small group.

Module Content:

The electromagnetic force is one of the four fundamental forces of nature, and manifests around charged particles and electric currents. In 1861 James Clerk Maxwell published his now famous unifying equations, revealing for the first time that light is an electromagnetic phenomenon (and that the EM force is carried by photons). Learn about electrostatics and magneto−statics, and the encompassing nature of Maxwell's equations. Appreciate the implications of self−sustaining EM waves in a vacuum, and connect the speed−of−light directly to electromagnetic constants. Study electromagnetic effects in the laboratory, demonstrating various behaviours of fields, forces, and electric circuits.

In this module you will develop your skills in research enquiry and problem solving, analysis and evaluation, team and organisational working, interpersonal and communication skills, conceptualisation, and data synthesis.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Optics and Lasers

Module code: 5PAM1045 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to understand classical optical physics and associated physical phenomena and be able to describe and discuss topics in modern optics. It also aims to teach students to use their knowledge and physics / mathematics skills to solve conceptual and numerical problems and develop skills in experimental physics and written communication.

Intended Learning Outcomes:

Successful students will typically:

- be able to explain in detail core concepts in optical physics;
- be able to apply this understanding to explain natural phenomena;
- be able to demonstrate some knowledge of topics in modern optics.

Successful students will typically:

- be able to solve numerical and conceptual problems in optics;
- be able to independently search for, analyse and evaluate information on modern topics in optics;
- be able to write a scientific report on a topic in optics;
- be able to perform laboratory experiments working in a small group.

Module Content:

The study of light has a storied history in physics, leading to the discovery that it is an electromagnetic wave and then the development of special relativity and quantum electrodynamics. Students will learn the classical topics of light wave propagation, interference and diffraction, geometric optics, polarisation and Fourier optics. These are illustrated with applications such as the detection of gravitational waves and discovery of new extra−solar planets. Modern topics such as lasers and their applications, which have led to 5 Nobel prizes since 1955, will also be included.

Furthermore, the student will be able to choose a topic in modern optics for a more detailed investigation.

In this module you will develop your skills in autonomy and responsibility for actions, problem solving, information searching, analysis and evaluation and scientific writing.

Pre and Co requisites:

Pre requisites: Special Relativity and Quantum Physics (4PAM1066) OR The Physical Universe (4PAM1013)

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Thermodynamics

Module code: 5PAM1046 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to give a rounded introduction to thermodynamics and statistical mechanics, with key ideas of; probabilistic methods in describing the behaviour of a large number of particles, reversible and irreversible changes, the idea of recognising and counting observable states, classical equilibrium distributions, and the thermodynamics of radiation. It also aims to provide an Earth Sciences theme by using, where possible, examples that show the contemporary importance of these ideas to the biosphere.

Intended Learning Outcomes:

Successful students will typically:

- be able to express concepts and methods of statistical mechanics;
- understand the nature of thermodynamic states and processes;
- be able to explain the ways in which the statistical treatment of the microphysical processes in lead to the macroscopic description of a thermodynamic system;
- understand the issues in the philosophical arguments that have arisen in this subject e.g. in the arrow of time, various 'demons', and the limits to information.

Successful students will typically:

- be able to evaluate the number and density of states of a physical system and relate this to thermodynamic states;
- be able to calculate kinetic effects such as pressure and effusion through a small hole;
- be able to calculate changes in thermodynamic quantities in various types of process e.g. energy−conserving, adiabatic, isothermal and understand the physical importance of cyclic processes as engines, heat pumps etc;
- be able to interrogate partition functions and distribution functions.

Module Content:

Thermodynamics is one of the most fascinating areas of physics, bridging the divide between quantum and classical mechanics. In addition, because it deals with large numbers of particles, it reveals new collective types of behaviour such as changes of phase. Thermodynamics applies to large and small systems, from a bacteria and the household refrigerator to black holes and the universe in the large. As such it is an incredibly powerful tool and puts limits on the behaviour of systems, most famously in the law of entropy increase. These limitations have led to much philosophical debate and fascinating unanswered questions e.g. why does consciousness only seem to flow in one direction and how is this linked to other asymmetries in the universe such as the net increase in universal entropy. This module will allow you to confront these issues and solve foundational problems that help understand their complexity and subtlety.

The module develops skills in research enquiry and problem solving, analysis and evaluation, interpersonal and communication skills, scientific writing and information searching, and conceptualisation and critical thinking.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Physics of the Solar System

Module code: 5PAM1050 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to apply core physics concepts to the study and understanding of solar system bodies and processes. It also aims to teach students to use their knowledge to carry out numerical/analytical exercises to study and interpret the properties of solar system objects, and obtain datasets from telescope and large astronomical archives/databases which they will analyse for science.

Intended Learning Outcomes:

Successful students will typically:

- be able to explain the main topics in planetary science (physics of the solar system);
- be able to use core physics concepts to study solar system objects and processes.

Successful students will typically:

- be able to interpret and analyse numerical/analytical model/observed data for a selection of objects/processes;
- be able to use astronomical data sets from a public archive/database and analyse for science;
- be able to apply observatory skills to the study of solar system phenomena;
- be able to implement practical activities as part of small group.

Module Content:

With the advent of the space age "Planetary Science" (the physics of the solar system) is the only branch of astronomy in which up−close studies are possible, with lunar missions and interplanetary probes revolutionizing our understanding over the past 50 years. Learn about the diverse range of solar system bodies and their dynamics, how planets form, their interiors/surfaces and ring systems, planetary and inter−planetary magnetic effects, and the possibilities for life elsewhere in the solar system.

In this module you will develop your skills in research enquiry and problem solving, analysis and evaluation, team and organisational working, interpersonal and communication skills, scientific writing and information searching, critical thinking, and data synthesis.

Pre and Co requisites:

Pre requisite: The Physical Universe (4PAM1013)

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Extra−Solar Planets

Module code: 5PAM1051 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to acquire a broad knowledge about the physics of extra−solar planets, and apply core physics concepts to their study and understanding. It also aims to teach students to use their knowledge to carry out numerical/analytical work concerned with the properties of extra−solar planets, and develop practical observing skills in measurement taking and written communication in the field.

Intended Learning Outcomes:

Successful students will typically:

- be able to explain the main topics in extra−solar planets;
- be able to use core physics concepts to study the properties and observed population characteristics of extra−solar planets.

Successful students will typically:

- be able to analyse and interpret numerical/analytical model/observed data for a selection of extra−solar planets;
- be able to apply observatory skills to the study of extra−solar planets;
- be able to implement practical activities as part of small group.

Module Content:

In the past three decades extra−solar planets have moved from science fiction to science−fact, with ground− and space−based surveys revealing several thousand extra−solar worlds. Learn about the methods for extra−solar planet discovery, their interiors and atmospheres, the diversity of known systems and their formation. Study the physics of this hugely diverse population, and understand how astronomers assess extra−solar habitability. Learn about future missions aiming to reveal the conditions in extra−solar planet atmospheres, and study the criteria for extra−solar life and SETI initiatives.

In this module you will develop your skills in research enquiry and problem solving, analysis and evaluation, team and organisational working, interpersonal and communication skills, scientific writing and information searching, and data synthesis.

Pre and Co requisites:

Pre requisite: The Physical Universe (4PAM1013)

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Plasma Physics and Fusion Reactors

Module code: 5PAM1052 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to understand the behaviour of plasmas and their interaction with electric and magnetic fields, and about the nuclear physics of fusion reactions. It also aims to teach students to derive design requirements for a fusion reactor.

Intended Learning Outcomes:

Successful students will typically:

- understand kinetic and fluid models of plasma;
- be able to explain the nuclear reactions relevant for controlled fusion.

Successful students will typically:

- be able to apply plasma models to solve problems related to controlled fusion and plasma in general;
- be able to apply nuclear physics in the context of controlled fusion;
- be able to work in a team to do literature research and present the results.

Module Content:

Plasma is a gas in which most atoms are ionised. This gives it properties which are quite different from gases as we know them. Plasmas are very good conductors of electricity. Their behaviour is dominated by long range electric and magnetic fields, not by short distance particle−particle interactions. Plasmas appear in nature in the solar corona, lightning strikes and polar aurorae. Plasmas have also many technical applications: fluorescent lamps, plasma etching of computer chips, TV screens and fusion research. This module will study the behaviour of charged particles in electric and magnetic fields. A fluid model will be developed to describe the collective behaviour (magneto hydrodynamics). The nuclear physics of fusion reactions will be introduced and requirements for a fusion plasma derived. Students will research physical, technical and practical aspects of designing and running a fusion reactor.

The module develops skills in research enquiry and problem solving, interpersonal and communication skills, information searching, and conceptualisation and critical thinking.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
70%	30%	0%

Module name: Space Science and Systems

Module code: 5PAM2000 Semester: A Credits: 15

Module Aims:

The aims of this module are to understand some of the core physical ideas that underlie the development and analysis of space systems and the physical principles of space science. This will provide a good foundation for a later deeper appreciation of the engineering construction and performance issues associated with these systems and for more advanced treatments of space science. Space systems can be broadly classified: structure; power; thermal; propulsion; electromagnetics (compatibility, charging environment); mechanical testing and stability; communication. From this ensemble, the student will be introduced to some key ideas that will help shape their physical insight into spacecraft design. Space Science deals with imaging, remote sensing, in-situ physical measurements (e.g. of ambient magnetic fields), geodesy and other physical characterisation of solar system objects.

Intended Learning Outcomes:

Successful students will typically:

- Have a sound introductory understanding of how physical principles underlie a selection of the key themes of space systems. The idea is not be exhaustive but to indicate how physics and engineering design go hand-in-hand;
- Understand the power of dimensional analysis as a useful precursor to advanced systems design;
- Know how to use and develop their knowledge of core physics ideas in specific problems and scenarios relevant to space science.

Successful students will typically:

- Be able to apply dimensional analysis to physical problems relevant to space systems and space science;
- Be able to analyse spacecraft images and identify image parameters (field of view, pixel scale, use of multispectral imaging);
- Be able to explain physical processes in and around spacecraft using relatively simple calculations and with accurate technical sketches (e.g. of shock waves, electric fields etc.);
- Be able to work in a group to analyse a particular area of a mission or system specification and communicate the results effectively to a non-specialist audience.

Module Content:

- The use of dimensional analysis in systems (a theme of the module, to include an introduction to various non-dimensional measures of mechanical and thermal properties)
- Typical topics in this module cannot be exhaustive but should give a sound grounding in the physical principles underlying engineering design. Notional topics to include:
- Heat transfer and exchange
- Introduction to flows and types of flow (pipes, nozzles, Knudsen, hypersonic etc.)
- Gyroscopic stability
- Essentials of radio and laser communication
- Imaging systems, image analysis, remote sensing
- Simple stress analysis
- Electrostatic charging and the physics of electrical discharge

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Multivariable Calculus

Module code: 5PAM2012 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to develop an understanding of multiple integrals, vector calculus, and the Fourier transform. It also aims to explore the concept of an analytic function and contour integration.

Intended Learning Outcomes:

Successful students will typically:

- be able to define and use multiple integrals and vector calculus;
- be able to demonstrate knowledge and understanding of the Fourier transform;
- be able to demonstrate understanding of analytic functions and contour integration.

Successful students will typically:

- be able to perform multiple integrals in unfamiliar problems, including changing the order of integration and changing coordinates;
- be able to perform calculations involving vector calculus and analytic functions of complex variables;
- be able to determine the Fourier transform of a function.

Module Content:

You will learn how to integrate functions of two and three variables along plane and space curves and how to evaluate multiple integrals of such functions. You will learn about gradient, divergence and curl. You will be able to obtain the Fourier transform of a function and perform calculations involving analytic functions of a complex variable.

In this module you will develop your skills in mathematical problem solving, and analysis and evaluation.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Algebra

Module code: 5PAM2013 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to understand and work with topics in abstract algebra, including permutations, relations on sets, and groups. It also aims at enabling students to write rigorous mathematical arguments using these concepts.

Intended Learning Outcomes:

Successful students will typically:

- be able to demonstrate knowledge and understanding of permutations of finite sets, and relations on sets;
- be able to demonstrate knowledge and understanding of the definitions of a group, a subgroup, a group action on a set, and of a homomorphism of groups;
- be able to demonstrate knowledge and understanding of results in group theory, including Lagrange's theorem and the orbit-stabilizer theorem.

Successful students will typically:

- be able to perform calculations with permutations in various notations, including disjoint cycle notation;
- be able to perform calculations with abstract groups and with concrete (e.g. matrix) groups;
- be able to apply theorems in group theory to examples, to compute for example the orders of symmetry groups.

Module Content:

This module introduces several core topics in abstract algebra. A recurring theme is of building from concrete examples to abstract and unifying mathematical ideas. We start with permutations on finite sets of objects, and develop techniques for working with them. We then introduce the concepts of relations on sets. We proceed to introduce one of the most important concepts in mathematics: that of a group. We discuss the group axioms in detail and show how they are motivated by means of various naturally occurring examples; we stress the idea of groups as groups of transformations of some object. Key results in group theory, including Lagrange's theorem and the orbit-stabilizer theorem, are stated and proved, and examples are given to show their utility and power.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Real Analysis
Module code: 5PAM2014 Semester: B Credits: 15

Module Aims:
The aims of this module are to enable students to understand and work with the foundational concepts in real analysis – bounds, limits, continuity, and differentiability – in the context of real sequences and real-valued functions. It also aims to teach students to write rigorous mathematical arguments using these concepts.

Intended Learning Outcomes:
Successful students will typically:
- Be able to demonstrate an understanding of the key defining axiom of the real numbers concerning least upper bounds;
- Be able to demonstrate a good conceptual grasp of the definitions of convergence of a sequence of real numbers, continuity and differentiability of a real-valued function;
- Be able to demonstrate an understanding of the concept of convergence of a real-valued series.

Successful students will typically:
- Be able to formulate and correctly express mathematical proofs in general, and in Analysis in particular;
- Be able to apply standard theorems of analysis (e.g. Rolles Theorem) in ways novel to them;
- Be able to apply standard test to determine whether or not a series converges.

Module Content:
This module introduces Real Analysis, one of the core topics in pure mathematics. We deal mainly with real-valued sequences and functions of a single real variable, and the central concepts we introduce is the precise definition of what it means for such sequences to converge and such functions to be continuous. The definitions are beautiful and yet notoriously subtle. In building up to it, we isolate the key property which distinguishes the real numbers from other number systems: that of completeness. We go on to give a similarly precise treatment of differentiability of functions. In the concluding section of the course, we look at series, which are sums of infinitely many real numbers, and when such a sum converges to a limit.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Differential Equations

Module code: 5PAM2015 Semester: B Credits: 15

Module Aims:
The aims of this module are to enable students to demonstrate comprehension and understanding in the topics of differential equations and develop technical skills in comparing alternative methods and techniques for using differential equations in applications. It also aims to teach students to consolidate the techniques for solving differential equations.

Intended Learning Outcomes:
Successful students will typically:

- be able to recognise the different forms of differential equations and select appropriate approaches to solving them analytically.

Successful students will typically:

- be able to construct appropriate (solvable) mathematical models using differential equations;
- be able to solve first, second and higher order differential equations analytically;
- be able to use the Laplace transforms to solve differential equations;
- be able to use matrix methods to represent and solve simultaneous differential equations;
- be able to use power series to solve differential equations.

Module Content:
This module employs a variety of mathematical methods and techniques to explore, describe and predict the behaviour of scientific, industrial and engineering phenomena. The subject appeals to individuals interested in applying mathematics to real-word problems. In this module, we focus on ordinary differential equations. The emphasis is on the development of methods important in applications.

In this module you will develop your skills in problem solving, analysis and evaluation.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Programming

Module code: 5PAM2016 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to understand the general principles of computer programming and be able to apply them in an appropriate high-level programming language.

Intended Learning Outcomes:

Successful students will typically:

- be able to demonstrate understanding of common features of high-level programming languages such as arithmetic operators and operations, built-in functions, data structures (e.g. arrays), loops, branching statements, input-output statements, subprograms and file handling;
- be able to explain the importance of program clarity and program documentation;
- be able to demonstrate knowledge of debugging procedures.

Successful students will typically:

- be able to design, write, test and debug simple programs and produce documentation with limited supervision and direction;
- be able to apply a wide range of programming techniques and make an informed choice of solutions to unfamiliar problems;
- be able to use their programing skills to modify more complex programs.

Module Content:

Programming is an important skill in the modern working world. This module will introduce you to programming in a modern high-level language. The module will cover control structures such as loops and logical statements. You will be shown how to build more complex programs by writing and linking separate functions and procedures. You will learn how to debug programs and produce program documentation. And you will apply your skills to a mathematical or physical problem and computationally analyse the results.

The module develops skills in computer programming, interpersonal and communication skills, and conceptualisation and critical thinking.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Motion and Tensors
Module code: 5PAM2018 Semester: A Credits: 15

Module Aims:
The aims of this module are to enable students to solve problems in dynamics using a range of mathematical structures, and to analyse a dynamical problem to provide an appropriate mathematical description of it. It also aims to teach students to recognise that problems in dynamics are often best dealt with in particular frames of reference.

Intended Learning Outcomes:
Successful students will typically:

- be able to explain core concepts of dynamics including states, equations of motion, frames of reference, and symmetry;
- be able to demonstrate understanding of specific applications of the core concepts to mechanics, including generalised coordinates, momentum, energy, and oscillations.

Successful students will typically:

- be able to use and apply a range of mathematical concepts, including tensors, frames and transformations between frames;
- be able to solve problems in dynamics using complementary approaches;
- be able to manipulate tensors and vectors using suffix notation and summation convention; and apply such manipulations to dynamical problems and changes of coordinates;
- be able to set up equations to model problems in classical mechanics.

Module Content:
Dynamics in mathematics has a broad meaning and describes states and state spaces, and the transformation or evolution of these states. This module highlights these ideas while focusing on problems of classical mechanics. The approach will emphasize the (historically accurate) way in which mathematical structures have often been devised to solve particular mechanical problems. You will learn how to work in different frames, both inertial and non-inertial. You will use tensors to simplify and solve complex problems, and to reveal their intrinsic symmetries.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Number Theory

Module code: 5PAM2019 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to develop an understanding of number theory, and teach them the concepts and techniques required to understand and to solve problems in number theory.

Intended Learning Outcomes:

Successful students will typically:

- Be able to recognise the use of Euclid's algorithm for finding greatest common denominator, and solving linear Diophantine equations;
- Be able to recognise problems concerning proofs and distribution of the prime numbers;
- Be able to demonstrate knowledge and understanding of modular arithmetic.

Successful students will typically:

- Be able to perform calculations to find greatest common denominator, and solve linear Diophantine equations;
- Be able to apply relevant techniques to solve problems in modular arithmetic and congruences.

Module Content:

Number theory is one of the oldest branches of mathematics and is concerned with the properties of integers. It has many practical applications, most importantly in areas such as cryptography. This module will look at divisibility among integers, the Euclidean algorithm and factorization into prime numbers, and it will investigate the distribution of the primes. It will also introduce modular ("clock") arithmetic that leads to the investigation of congruences, Fermat's little theorem, Chinese remainder theorem, and quadratic reciprocity. It will discuss Euler's phi function, and other topics such as Diophantine equations and continued fractions. Most of the content of the module will be placed in an historical context.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Investment Portfolios

Module code: 5PAM2020 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to gain an understanding of modern financial theories relating to portfolio selection. The students will analyse the performance of a portfolio of risky securities and fixed income securities, and explore the methods used to minimise the risk or optimise the expected return associated with the portfolio, depending on the needs of different investors.

Intended Learning Outcomes:

Successful students will typically:

- Be able to explore the extent to which securities in a market behave independently or are correlated with other assets in the same market in modern portfolio theory;
- Be able to demonstrate understanding of the concepts of investment risk and expected return, and be able to expand these concepts from single securities to portfolios;
- Be able to explain the techniques used to analyse portfolios of securities and interpret the results of these analyses.

Successful students will typically:

- Be able to use software to construct, analyse and optimise portfolios of securities;
- Be able to calculate risk and expected return from market data;
- Be able to recommend and communicate appropriate investment strategies for different investors.

Module Content:

This module investigates the construction and mathematical analysis of portfolios of securities. A variety of techniques from modern portfolio theory are introduced to analyse the risk and expected return of a portfolio, and applied to the construction of efficient and optimal portfolios. Live financial market data will be downloaded from the internet and used in practical computing sessions to demonstrate the concepts and theories discussed in lectures. The students have the opportunity to create their own portfolio of assets and participate in a friendly competition to achieve the highest performing portfolio.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
50%	50%	0%

Module name: Financial Markets

Module code: 5PAM2021 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to gain an understanding of a range of theories and models relating to the mechanism of the financial markets and the behaviour of investors. In earlier modules, students were introduced to individual investments and asset portfolios. In this module, our gaze is broadened to consider the financial market as a whole.

Intended Learning Outcomes:

Successful students will typically:

- be able to describe the assumptions and results of single-index model, the multi-index model and two of the most widely used asset pricing models;
- be able to explain the main theories of investor behaviour;
- be able to demonstrate understanding of market risks and how to model them.

Successful students will typically:

- be able to perform calculations of risk and expected return, using different techniques depending on the choice of underlying market model;
- be able to analyse and evaluate the likely behaviour of investors in different situations;
- be able to give a presentation on a current financial topic of interest, either in the UK or internationally.

Module Content:

The module investigates some of the most widely used theories and models relating to the mechanism of financial markets and the behaviour of investors. We will start by developing the single-index and multi-index models. We will then expand these investment models to apply to the market as a whole, introducing two widely used asset pricing models, the Capital Asset Pricing Model and Arbitrage Pricing Theory. We will consider the controversial topic of the Efficient Market Hypothesis, examining the research into market anomalies and the potential implications for analysts and investors when making investment decisions. We will move on to discuss investor behaviour, starting with traditional utility theory and how it can be applied to many real-life examples, including the insurance market. We will compare this to the emerging field of behavioural finance, introducing the idea that investors do not always act in a rational manner.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
50%	50%	0%

Module name: Numerical Methods
Module code: 5PAM2022 Semester: B Credits: 15

Module Aims:
The aims of this module are to enable students to appreciate the need for numerical algorithms for solving problems. It also aims to teach students to understand and be able to use a range of numerical algorithms.

Intended Learning Outcomes:
Successful students will typically:
- Be able to demonstrate understanding of rounding to a specified precision;
- Be able to demonstrate understanding of standard algorithms for solving numerical problems;
- Be able to appreciate the relative merits and limitations of methods for particular problems.

Successful students will typically:
- Be able to describe, compare and select appropriate numerical methods for particular problems;
- Be able to apply numerical methods to obtain approximate solutions to mathematical problems;
- Be able to solve problems using computer implementations of numerical methods.

Module Content:
Numerical techniques are important across many areas of mathematical modelling, since it is rare that real-world problems admit solutions in closed form. In this module you will discover how to use numerical methods to solve mathematical problems. We will discuss the relative performance of different methods in terms of accuracy and efficiency, and investigate the theoretical background to the methods.

We will typically cover methods for numerical integration, numerical solution of systems of linear equations, computation of eigenvectors and eigenvalues, and the numerical solution of systems of ODEs.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Game Theory

Module code: 5PAM2023 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to understand basic concepts in game theory and apply them to simple games.

Intended Learning Outcomes:

Successful students will typically:

- Be able to describe simple games using game trees and game tables, and to explain key concepts such as winning, dominant, pure and mixed strategies, and best responses;
- Be able to demonstrate knowledge and understanding of basic concepts of game theory, such as dominant strategies and Nash equilibria.

Successful students will typically:

- Be able to describe sequential games using game trees, and to use appropriate methods to solve such games;
- Be able to find pure and mixed Nash equilibria of simultaneous games;
- Be able to recognise game theory applications in various areas of real life, and interpret the implications of game theory in real-world situations.

Module Content:

Famous since at least the Nobel-prize winning work of John Nash, game theory analyses situations in which payoffs to players depend on their behaviour as well as behaviour of other players.

Game theory has found many applications in various fields, such as economics, biology, business, law, politics, sociology, computer science and data science. The purpose of this module is to introduce the fundamentals of game theory, including the concept of Nash equilibria. It focuses on various ways of describing and solving games, and their applications in real-world situations. The students will learn how to recognize and model strategic situations, to predict when and how their action will have an influence on others, and to exploit strategic situations for the benefit of their own.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Statistical Modelling

Module code: 5PAM2024 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to use analysis of variance and regression analysis modelling techniques appropriately, with the aid of a statistical computer package. It also aims to teach students to understand some of the issues associated with the modelling techniques considered.

Intended Learning Outcomes:

Successful students will typically:

- Be able to demonstrate a knowledge and understanding of regression analysis and the analysis of variance techniques;
- Be able to demonstrate a knowledge and understanding of the use of a statistical package to carry out analysis of variance and regression analysis.

Successful students will typically:

- Be able to apply regression analysis and analysis of variance techniques to data;
- Be able to make appropriate use of a statistical computer package to apply the modelling techniques taught on this module;
- Be able to communicate the findings of a statistical analysis in the form of a written report.

Module Content:

Statistical modelling refers to a set of tools and techniques for modelling and understanding complex data sets and plays a key role in many areas of science, medicine, finance and industry. This module has been developed to give students a detailed understanding of the commonly used statistical modelling techniques of analysis of variance and regression analysis.

The module is supported throughout by the use of a statistical computer package which facilitates the analysis of data sets, taken from a variety of application areas, using the methods taught in the lectures.

Pre and Co requisites:

None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Quantum Mechanics

Module code: 5PAM2025 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to understand and apply the formal structure of quantum mechanics, using their knowledge to carry out analytical and numerical exercises to study and interpret the properties of bound states, spin states, and identical particles. It also aims to teach students to use this knowledge to investigate the process of tunnelling and the structure of atoms and molecules, as well as an appreciation of modern conceptual problems and the non-classical behaviour of quantum systems.

Intended Learning Outcomes:

Successful students will typically:

- be able to demonstrate understanding of the basic formalism of quantum mechanics;
- be able to explain how the formalism is used to solve problems involving bound and free states;
- be able to describe the properties of spin and atomic, molecular and nuclear structure.

Successful students will typically:

- be able to solve a variety of problems using the basic formalism of quantum mechanics;
- be able to calculate properties of various physical systems;
- be able to analyse and discuss a recent development or application of quantum mechanics.

Module Content:

Quantum mechanics is the most fundamental and most successful theory of the physical world. It has been essential to the development of many modern technologies (lasers, solid state and tunnelling devices, entanglement and encryption). This module develops the basic formalism of quantum mechanics. The formalism is used to understand the properties of bound states, spin states, identical particles and multi-particle structures. Recent developments and conceptual problems are also discussed.

The module develops skills in research enquiry and problem solving, presentation skills, conceptualisation and critical thinking.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Space Dynamics
Module code: 6PAM0027 Semester: B Credits: 15

Module Aims:
The aims of this module are to enable students to understand and apply core physics concepts to the area of space dynamics, including orbital trajectories, orbital stability, the influence of non−gravitational forces, and the spin dynamics of spacecraft. It also aims to provide students with experience in numerical methods and the visualisation of dynamical problems.

Intended Learning Outcomes:
Successful students will typically:

- be able to summarise the core physics concepts and their application in orbital and rotational dynamics;
- understand practical techniques in numerical modelling of dynamics applied to astronautics;
- be able to explain the physical processes that govern the orbits of spacecraft.

Successful students will typically:

- be able to select appropriately between analytical and numerical approaches to solving problems in space dynamics;
- be able to model the orbital and rotational physics of spacecraft using computational methods;
- be able to take responsibility for their own learning via the group space mission development project, appraising alternative plans and communicating the conclusions effectively.

Module Content:
Space dynamics is a coursework−only module. Students work in a computer lab supervised by the module facilitator. There are no formal lectures. Instead, students work their way through a set of computer exercises using Matlab. The exercises allow the student to tackle problems in different ways and develop their own style of problem−solving. The module covers various aspects in spacecraft dynamics including: atmospheric drag, aerobraking, transfer orbits, injection orbits, spacecraft spin, the stability of spinning motion — Euler's equations, three−dimensional spin motion, and mass models of irregular objects.

The module develops skills in research enquiry and problem solving, analysis and evaluation, interpersonal and communication skills, autonomy and responsibility for actions.

Pre and Co requisites:

Pre requisite: 4PAM2018 Computational Modelling

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Computational Physics

Module code: 6PAM1004 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to develop their basic computational and computer modelling skills and apply them to investigate problems in physics and astrophysics via hands−on workshops conducted in a computer laboratory.

Intended Learning Outcomes:

Successful students will typically:

- have an extended knowledge and understanding of various physical phenomena by computer modelling;
- understand the computational techniques used to study physical problems;
- be able to analyse and present the results of a computer modelling investigation.

Successful students will typically:

- be able to apply basic programming skills to solve physical problems;
- be able to apply basic physics knowledge and research to interpret the results of a computer model;
- be able to report the results of a computer study in a professional manner.

Module Content:

In this module you will develop your computational skills by investigating problems in physics and astrophysics. You will have the opportunity to use and modify numerical programmes written in languages such as Python and Matlab. The module is delivered in a hands−on workshop environment in a computer laboratory. You will typically study two or three problems and assessment is based on a report you write on each of your investigations.

In this module you will develop your skills in research enquiry, computer programming/modelling, scientific writing, and critical thinking.

Pre and Co requisites:
Pre requisite: 4PAM2018 Computational Modelling

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Complex Analysis
Module code: 6PAM1020 Semester: A Credits: 15

Module Aims:
The aims of this module are to enable students to become familiar with fundamental ideas of complex analysis, extend the ideas developed in Real Analysis from real to complex numbers and develop the theory of analytic functions, and to apply this theory to understand problems arising in real analysis or calculus.

Intended Learning Outcomes:
Successful students will typically:
- understand functions of a complex variable, and how they differ from their real counterparts;
- understand ideas of continuity and differentiability on the complex plane;
- understand path and contour integrals.

Successful students will typically:
- describe geometrically and work with sets of complex numbers;
- investigate the properties of complex functions;
  perform integration of complex functions, and apply this to solve real integrals.

Module Content:
Complex Numbers are two dimensional, and are an unordered set. This leads to many startling and bizarre ideas. We apply the ideas of continuity and differentiability to functions of a complex variable, and reach some surprising conclusions. However, it is when applying the ideas of integration that the most beautiful and impressive results emerge, with many practical applications.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
80%	20%	0%

Module name: Partial Differential Equations

Module code: 6PAM1023 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to recognise partial differential equations and choose appropriate method for its solution, and know where and how partial differential equations arise in applications.

Intended Learning Outcomes:

Successful students will typically:

- be able to describe real−world systems using Partial Differential Equations;
- be able to derive some important partial differential equations.

Successful students will typically:

- be able to solve partial differential equations by characteristic methods;
- be able to solve partial differential equations by separation variables;
- be able to understand and recognise Sturm Liouville systems;
- be able to use Green's functions in the solution of differential equations.

Module Content:

Partial differential equations arise as part of the mathematical modelling of real life problems connected to many areas of science. These connections must be exploited to find a solution to these problems. PDEs provide the foundation for a robust and important area of applied mathematics. In this module we will look at the derivation of some important PDEs and their classification schemes.

In this module you will develop your skills in problem solving, and analysis and evaluation.

Pre and Co requisites:

Pre requisite: 5PAM2012 Multivariable Calculus

Total hours: 150

Assessment:

Exam	Coursework	Practical
80%	20%	0%

Module name: Linear Optimisation

Module code: 6PAM1024 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to understand linear programming and to be able to solve associated problems.

Intended Learning Outcomes:

Successful students will typically:

- Have a knowledge and understanding of the modelling process in relation to linear programming;
- Have a knowledge and understanding of a range of LP algorithms and their relative merits;
- Have a knowledge and understanding of the problem cases that arise when solving LP problems.

Successful students will typically:

- formulate LP models from given data;
- critically select and then apply algorithms to LP models;
- interpret solutions of LP models.

Module Content:

You learn to extract the relevant information from business problems and to develop linear programming models to represent them. A number of different solution methods are developed and used to solve these problems. You will develop the ability to interpret the solutions in practical terms and deal with the problem cases that sometimes arise when solving LP problems.

Pre and Co requisites:

Pre requisite: 4PAM2006 Mathematical Methods

Total hours: 150

Assessment:

Exam	Coursework	Practical
70%	30%	0%

Module name: Nonlinear Optimisation

Module code: 6PAM1028 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to understand how optimization problems arise in real world and identify appropriate solution methods to solve them; and develop an understanding of the fundamentals of nonlinear optimisation.

Intended Learning Outcomes:

Successful students will typically understand:

- unconstrained and constrained formulations of nonlinear optimisation problems;
- fundamental methods and use of software for nonlinear optimisation.

Successful students will typically be able to:

- apply an appropriate algorithm or numerical method for solving a particular problem;
- discuss the relative advantages and limitations of the various algorithms;
- understand the derivation and uses of the optimality conditions;
- use given implementations of these algorithms in Matlab and analyse results.

Module Content:

You will learn and explore the fundamentals of nonlinear optimisation problems, both unconstrained and constrained and how to solve them using a number of different iterative techniques. Blending theory and algorithms for solving nonlinear optimisation problems with applications to real world problems such as in finance. You will study the convergence properties of these iterative methods and learn how to use software implementations of them.

Pre and Co requisites:

Pre requisites: 5PAM2012 Multivariable Calculus and 5PAM2022 Numerical Methods

Total hours: 150

Assessment:

Exam	Coursework	Practical
80%	20%	0%

Module name: Combinatorics

Module code: 6PAM1029 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to identify and define a range of discrete mathematical structures and their properties, apply various combinatorial techniques, and recognise and solve combinatorial problems.

Intended Learning Outcomes:

Successful students will typically have a knowledge and understanding of:

- several important types of discrete mathematical structures;
- key properties of such structures;
- common problems and questions relating to these structures and properties;
- techniques to solve and answer those problems and questions respectively.

Successful students will typically be able to:

- express and identify discrete problems in terms of the appropriate mathematical language;
- apply different combinatorial techniques;
- analyse, explore and solve unseen problems by comparing them to known problems.

Module Content:

Combinatorics is the study of finite or countable, discrete structures; as opposed to uncountable, continuous structures such as the real or complex numbers studied in Analysis and Calculus. Graphs (think of a system of islands connected by bridges) and Latin Squares (a completed Sudoku puzzle is an example of a Latin Square) are two examples of the kind of object Combinatorists are particularly interested in, but there are many more. Combinatorial problems are just as varied as Combinatorial objects and include questions such as "How many different number plates can there be?", "If you shuffle a playlist, what are the odds that at least one song is in its original position", or Can you find six people so that no three of them are all mutual friends, but no three of them are all mutual strangers?".

Pre and Co requisites:

Pre requisite: 4PAM2010 Numbers and Sets

Total hours: 150

Assessment:

Exam	Coursework	Practical
80%	20%	0%

Module name: Nonlinear Systems

Module code: 6PAM1030 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to investigate problems modelled by nonlinear differential equations and evaluate the qualitative behaviour of their solutions.

Intended Learning Outcomes:

Successful students will typically:

- have an understanding of phase portraits;
- have a systematic understanding of the bifurcation behaviour of families of 1−dimensional differential systems.

Successful students will typically:

- be able to evaluate, analyse and determine the qualitative behaviour of the solution of differential equations via phase portraits;
- be able to evaluate, interpret and explore the behaviour of differential systems using local linearisations about fixed points;
- be able to explore and analyse the behaviour of nonlinear systems by application of appropriate software.

Module Content:

You will learn how to investigate and evaluate the qualitative behaviour of the solutions of differential equations which relate to problems in a wide variety of application areas. You will recognise that the behaviour of the solution of a differential equation can be drastically altered by a small change in a parameter. These observations have important contributions in improving the applications of mathematics in industry, business and the physical sciences. The module provides the student with an understanding of differential equations by the construction, analysis and interpretation of phase portraits. In particular you will be able to identify if and when periodic solutions and other types of behaviour exist.

The module develops skills in problem solving, analysis and evaluation, team and organisational working, interpersonal and communication skills, and conceptualisation.

Pre and Co requisites:
Pre requisite: 4PAM2006 Mathematical Methods

Total hours: 150

Assessment:

Exam	Coursework	Practical
80%	20%	0%

Module name: Financial Mathematics & Derivative Pricing
Module code: 6PAM1031 Semester: AB Credits: 30

Module Aims:
he aims of this module are to enable students to value financial derivatives and critically evaluate financial models for securities and derivative pricing.

Intended Learning Outcomes:
Successful students will typically have a knowledge and understanding of:

- stochastic models for the behaviour of security prices and the concepts of Brownian motion;
- the properties of option prices, valuation methods and hedging techniques;
- models for credit risk.

Successful students will typically:

- critically evaluate and apply stochastic pricing models;
- analyse and apply valuation techniques and hedging strategies;
- derive, evaluate and apply Black–Scholes model;
- critically evaluate approaches to credit risk.

Module Content:

The aim of the module is develop, analyse and implement financial models for security prices and the valuation of derivative contracts. Initially the concept and techniques of stochastic processes will be introduced. This will lead to the analysis of the lognormal random walk which is used to model the behaviour of security prices. This model will be compared and contrasted with alternative models. The notion of stochastic calculus will be introduced and in particular Ito's lemma which is a fundamental technique used in evaluating the change in a function of a random variable.

The financial concepts of arbitrage and hedging will be defined and applied to the Black−Scholes model to develop the infamous associated partial differential equation. Analytical solutions will be developed and used to price derivative contracts. The binomial option pricing model will be constructed and used to price a variety of option contracts and compared with the Black−Scholes model. Finally Credit Risk models will be defined, compared and contrasted.

Pre and Co requisites:

Pre requisites: 5PAM2020 Investment Portfolios and 5PAM2021 Financial Markets

Total hours: 300

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Multivariate Statistics

Module code: 6PAM1036 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to understand and apply various multivariate data analysis techniques.

Intended Learning Outcomes:

Successful students will typically have a knowledge and understanding of:

- the appropriate implementation of multivariate data analysis;
- the interpretation of results from multivariate data analyses.

Successful students will typically be able to:

- display and describe multivariate data, and interpret and report the results of analysing multivariate data;
- use appropriate statistical packages for various methods of multivariate data analysis.

Module Content:

This is a module in statistics for students who wish to study techniques widely used by statisticians working in research, commerce and industry. Multivariate statistics introduces techniques for examining relationships among a group of variables, and a number of multivariate statistical methods are introduced. Throughout the module, computer packages are used wherever relevant to analyse case studies relating to the techniques taught.

The main topics studied are likely to include:

−methods of viewing multivariate data;

–how to describe multivariate data in a statistical manner;

–how to conduct hypothesis tests using multivariate data;

–how to carry out various methods of multivariate data analysis;

–how to interpret the results of various methods of multivariate data analysis.

Pre and Co requisites:
Pre requisite: 4PAM2024 Statistical Modelling

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Linear Modelling
Module code: 6PAM1037 Semester: A Credits: 15

Module Aims:
The aims of this module are to enable students to understand and apply the statistical analysis of linear models.

Intended Learning Outcomes:
Successful students will typically:

- Have a knowledge and understanding of the technical background behind the various forms of the general linear model;
- Understand when to use the various forms of the general linear model appropriately.

Successful students will typically:

- Be able to implement the various forms of the general linear model;
- Use appropriate statistical packages for various methods of linear modelling;
- Interpret results from the various forms of the general linear model.

Module Content:

This is a module in statistics for students who wish to study techniques widely used by statisticians. Linear modelling brings together regression and analysis of variance into a single modelling approach based on matrix algebra and extends these methods to include category response variables.

The main topics studied are likely to include:

-the matrix algebra approach to linear regression;

-methods of analysing non–orthogonal sums of squares;

-the dummy variables approach to the analysis of experimental design models;

-the analysis of contingency tables by use of log−linear models;

-logistic regression;

-the principles of the generalised linear model.

Pre and Co requisites:
Pre requisite: 5PAM2024 Statistical Modelling

Total hours: 150

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Condensed States of Matter
Module code: 6PAM1050 Semester: A Credits: 15

Module Aims:
The aims of this module are to enable students to understand the basic properties of condensed matter states. It also aims to teach students to use their knowledge to carry out numerical/analytical exercises and research a topic of current interest.

Intended Learning Outcomes:
Successful students will typically:
- be able to explain the properties of condensed matter including semi−conductor behaviour;
- understand the behaviour of fermions and bosons at low temperature;
- be aware of modern applications of condensed matter physics.

Successful students will typically:
- be able to calculate basic physical properties of condensed states of matter;
- be able to apply quantum physics to an understanding of many particle behaviours;
- be able to research technological applications of condensed states of matter.

Module Content:

This module covers the basic properties of condensed matter states. It demonstrates the application of quantum physics to many particle systems and discusses modern applications including, semi−conductors, degeneracy, and Bose−Einstein condensation. You will develop your skills of modelling, problem solving and research enquiry.

In this module you will develop your skills in problem solving and research enquiry, scientific writing and information searching.

Pre and Co requisites:
Pre requisite: 5PAM2025 Quantum Mechanics

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: The Physics of Elementary Particles
Module code: 6PAM1051 Semester: B Credits: 15

Module Aims:
The aims of this module are to enable students to gain a broad knowledge of the physics of elementary particles, and enable students to apply core physics concepts to particle interactions and decays. It also aims to teach students how to use their knowledge to carry out numerical or analytical exercises to study particle phenomena, and to interpret relevant types of experimental output.

Intended Learning Outcomes:
Successful students will typically:

- be able to explain the key topics in particle physics;
- be able to use core physics concepts to analyse particle interactions;
- be able to understand the design of particle accelerator experiments.

Successful students will typically:

- be able to numerically/analytically model a selection of particle scenarios.
- be able to interpret the type of output recorded by basic particle detectors.

Module Content:
The module will provide an account of the particle physics of the standard model, our most complete theory of the fundamental rules governing the microscopic nature of matter and forces. The material will cover everything from the early ideas of the start of the twentieth century through to the modern picture, which represents our current understanding and has only been confirmed much more recently by large international experiments, such as those based at CERN.

In this module you will develop your skills in problem solving and research enquiry, scientific writing and information searching, and conceptualisation.

Pre and Co requisites:
Pre requisites: 5PAM2012 Multivariable Calculus and 5PAM2025 Quantum Mechanics

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Physics Project and Investigative Skills
Module code: 6PAM1052 Semester: AB Credits: 30

Module Aims:
The aims of this module are to enable students to carry out a physics project, either in the form of a substantial literature review or consisting of a piece of research accompanied by a background review of the research topic (in either case the scope of the work should cover greater depth than is possible with other modules). It also aims to develop investigative skills, including drive, independence, organisation, communication, and writing/presenting skills.

Intended Learning Outcomes:
Successful students will typically:

- be able to acquire a strong knowledge and understanding of a research topic in physics;
- be able to review the scientific literature effectively;
- be able to acquire understanding of statistical analysis methods for a research topic;
- be able to implement a piece of research and/or a literature review on a research topic in physics.

Successful students will typically:

- be able to organise and plan a substantial literature review or research project;
- be able to implement an effective literature review for a research topic;
- be able to demonstrate understanding of statistical analysis methods for a research topic;
- be able to structure and produce a substantial science report;
- be able to present their work and debate/argue points of interest in a viva style setting;
- be able to follow good ethical practice (avoiding collusion and plagiarism) when working.

Module Content:

Students will carry out a piece of research and/or a literature review in a research topic. Physics research areas in the School include; atmospheric physics, theoretical physics, and medical physics. A successful project will become a feature of a student's professional profile and CV, and is often a talking point in graduate job interviews and/or postgraduate applications.

The module develops skills in research enquiry and problem solving, analysis and evaluation, organisational working, interpersonal and communication skills, scientific writing and information searching, conceptualisation and critical thinking, adaptation to context, synthesis and creativity, personal evaluation and development, and ethical awareness and application.

Pre and Co requisites:

None

Total hours: 300

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Geophysical Fluid Dynamics

Module code: 6PAM1053 Semester: B Credits: 15

Module Aims:

The aims of this module are to enable students to learn the basic principles governing the circulation of the Earth's atmosphere and ocean on large terrestrial scales. These principles are central to study in environmental and climate sciences.

Intended Learning Outcomes:

Successful students will typically:

- be able to formulate and describe the basics of fluid dynamics.
- be able to explain the dynamical controls on the climate system.

Successful students will typically:

- be able to investigate theoretically and numerically, various flow regimes in geophysical fluid dynamics.
- be able to investigate practically, various flow regimes in geophysical fluid dynamics.

Module Content:

This module gives a grounding in geophysical fluid dynamics, the basic principles governing the circulation of the Earth's atmosphere and ocean on large terrestrial scales. It provides a physical and mathematical description of geophysical flows and of an assortment of waves that can be supported by such flows. An emphasis is put on why the Earth's atmosphere and ocean look like they do on global scales. In–class demonstrations, laboratory experiments and computer modelling will feature.

In this module you will develop your skills in problem solving research and enquiry, analysis and evaluation, team and organisational working, interpersonal communicational skills, scientific writing and information searching.

Pre and Co requisites:
Pre requisite: 5PAM2012 Multivariable Calculus

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Astrophysics Project and Investigative Skills
Module code: 6PAM1054 Semester: AB Credits: 30

Module Aims:
The aims of this module are to enable students to carry out an astrophysics project, either in the form of a substantial literature review or consisting of a piece of research accompanied by a background review of the research topic (in either case the scope of the work should cover greater depth than is possible with other modules). It also aims to develop investigative skills, including drive, independence, organisation, communication, and writing/presenting skills.

Intended Learning Outcomes:
Successful students will typically:
- be able to acquire a strong knowledge and understanding of a research topic in astrophysics;
- be able to review the scientific literature effectively;
- be able to acquire understanding of statistical analysis methods for a research topic;
- be able to implement a piece of research and/or a literature review on a research topic in astrophysics.

Successful students will typically:
- be able to organise and plan a substantial literature review or research project;
- be able to implement an effective literature review for a research topic;
- be able to demonstrate understanding of statistical analysis methods for a research topic;
- be able to structure and produce a substantial science report;
- be able to present their work and debate/argue points of interest in a viva style setting;
- be able to follow good ethical practice (avoiding collusion and plagiarism) when working.

Module Content:
Students will carry out a piece of research and/or a literature review in a research topic. Astrophysics research areas in the School include; star formation in the Milky Way, the disc and bulge of the Milky

Way, extra–solar planets and brown dwarfs, planetary nebulae and white dwarfs, Active Galactic Nuclei physics and environment, the formation and evolution of galaxies, and the structure of galaxies. A successful project will become a feature of a student's professional profile and CV, and is often a talking point in graduate job interviews and/or postgraduate applications.

The module develops skills in research enquiry and problem solving, analysis and evaluation, organisational working, interpersonal and communication skills, scientific writing and information searching, conceptualisation and critical thinking, adaptation to context, synthesis and creativity, personal evaluation and development, and ethical awareness and application.

Pre and Co requisites:
None

Total hours: 300

Assessment:

Exam	Coursework	Practical
0%	100%	0%

Module name: Star Formation and Evolution
Module code: 6PAM1055 Semester: B Credits: 15

Module Aims:
The aims of this module are to enable students to develop a systematic understanding of the physics relating to star formation, stellar structure and stellar evolution, and to explore the key aspects of each.

Intended Learning Outcomes:
Successful students will typically:
- understand the physical theories and principles relating to star formation, stellar structure and stellar evolution;
- appreciate the current state of our understanding in this area of astrophysics and identify the main open questions;
- be able to recognise the key importance of physics, both at the microscopic and macroscopic levels, in the treatment of stars;
- understand how observation informs our knowledge of stellar physics.

Successful students will typically:
- be able to synthesise the key stages of star formation and stellar evolution and their underlying physics;
- be able to apply their knowledge and understanding of appropriate astronomical techniques to the analysis and interpretation of observational data, assessing the reliability and validity of the evidence to support their conclusions;
- be able to design and undertaking an observational programme to realise a science objective related to the course;
- be able to undertake detailed numerical calculations, including approximations, using relevant physics, to obtain a variety of stellar parameters.

Module Content:

The module will cover the fundamentals of stars and their structure, including their formation and evolution from the main sequence to final stellar remnants. It will develop an understanding of the principles and details driving the evolution of stars and the conditions in their deep interiors. Emphasis will be placed on the physics involved. An appreciation will be gained of the history of this field as well as the current open questions at the forefront of research. Lectures and discussions will present and develop the basic course material and concepts. Numerical assignments, practical reports, class tests and a final examination will allow and test consolidation of the learning outcomes. Observatory work will provide training in experimental and observational skills.

In this module you will develop your skills in problem solving and research inquiry, analysis and evaluation, team and organisational working, interpersonal and communication skills, and scientific writing and information searching.

Pre and Co requisites:

Pre requisites: 5PAM1046 Thermodynamics OR 5PAM1050 Physics of the Solar System

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Foundations of Cosmology

Module code: 6PAM1056 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to gain a physical understanding of contemporary cosmology by encountering the limitations of the classical (Newtonian) framework, and learning to appreciate the paradigm shift that is provided by Einstein's General Theory of Relativity (which is required to describe the geometry and overall characteristics of the Universe). It also aims to teach students to apply physical laws that have been developed under local conditions to the often−extreme conditions encountered in extragalactic astrophysics, viz. cosmology.

Intended Learning Outcomes:

Successful students will typically:

- have acquired knowledge about and understand the structure of expanding space−time;
- be able to demonstrate a deep understanding of the structure and evolution of the physical universe.

Successful students will typically:

- be able to formulate and solve problems in cosmology using appropriate mathematical treatments;
- be able to carry out independent background research, systematically and unsupervised, and communicate its findings;
- be able to report on work carried out at the observatory/laboratory in a clear and accurate manner, interpreting results and
- their inter−relationship with other fields of study where appropriate.

Module Content:

The study of the structure and evolution of the Universe has in the last few decades undergone a true transformation. Rather than theorists pursuing their models unencumbered by meaningful observational constraints, we now have entered the era of precision cosmology. This in no small part has been due to the tremendous technological advances that have allowed observational cosmologists to chart the structure of the Universe, all the way out to its observable edge. The module will cover the mathematical framework needed to describe expanding, curved space−time, i.e., the Robertson−Walker metric, and the concepts of Einstein's General Theory of Relativity as it applies to cosmology, in particular the Friedmann models. This is followed by an inventory of the constituents of the Universe, including Dark Matter and Dark Energy, and how theory and observations have led to the current consensus or Concordance model of the Universe.

In this module you will develop your skills in problem solving and research enquiry, analysis and evaluation, team and organisational working, interpersonal and communication skills, scientific writing and information searching, and conceptualisation.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: The Physics of Astronomical Spectra
Module code: 6PAM1057 Semester: A Credits: 15

Module Aims:
The aims of this module are to enable students to acquire knowledge and understanding about the physics and processes inherent in the generation of astronomical spectra. It also aims to teach students to appreciate how astronomical spectra can be analysed/studied to reveal properties and conditions of astronomical objects/regions, and to use their knowledge to carry out numerical/analytical exercises concerned with radiative processes and the interpretation of spectra.

Intended Learning Outcomes:
Successful students will typically:
- be able to justify and evaluate how astronomical spectra can be interpreted to yield information about the physical conditions and properties inherent to an object/region;
- be able to explain the physics involved in the generation of astronomical spectra.

Successful students will typically:
- be able to conceptualise and identify important radiative processes;
- be able to derive numerical/analytical data for some of the physical processes involved;
- be able to interpret numerical/analytical data for a selection of astronomical spectra.

Module Content:
From the nearest stars to the most distant galaxies (and the tenuous matter in between), astronomers can reveal and study properties and physical conditions by measuring the spectrum of the emitted radiation. Learn about the radiative processes that shape the variety of spectra encountered, and understand how astronomers discover the huge diversity of astronomical objects around us; the emergent radiation of stellar atmospheres and of giant glowing nebulae will be examined, along with the way in which spectroscopy picks up the imprint of the extremely low density inter−stellar medium. In this module you will develop your skills in research enquiry and problem solving, conceptualisation, and data synthesis.

Pre and Co requisites:
Pre requisite: Physics of the Solar System 5PAM1050 or Thermodynamics 5PAM1046

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: The Early Universe and Galaxy Formation
Module code: 6PAM1058 Semester: B Credits: 15

Module Aims:
The aims of this module are to enable students to gain a deeper understanding of the physical processes dominating the Early Universe, and investigate the processes that lead to structure formation in the Early Universe. It also aims to teach students to appreciate and critically evaluate the processes involved in Galaxy Formation and Evolution.

Intended Learning Outcomes:
Successful students will typically:
- have acquired knowledge about and understand the physical processes that governed in the Early Universe;
- be able to demonstrate a deep understanding of structure formation, and subsequent galaxy formation as the Universe evolves.

Successful students will typically:
- be able to formulate and solve problems related to the physical processes that governed in the Early Universe;
- select and apply the appropriate mathematical formalism needed to describe the physical phenomena prevailing when the Universe was in its infancy;
- be able to carry out independent background research, systematically and unsupervised, and communicate its findings.

Module Content:
A combination of incredible advances in observational techniques, i.e., large ground−based optical and radio telescopes, complemented with sophisticated space−based observatories, has made it possible to peer out to the edge of the observable Universe, effectively looking back in time when (proto−) galaxies first assembled. This module describes what the Universe was like from its earliest beginnings. It describes the oldest light that has reached us and what that teaches us about the fundamental parameters that describe the Universe, when the first structures formed under the

influence of gravity, and how these structures evolved into what in the nearby Universe we call galaxies. In the course of this module topic coverage will include Inflation, Big Bang nucleosynthesis, the era of Recombination and the Cosmic Microwave Background, Large Scale Structure formation, the Jeans law and Galaxy Formation, the formation and characteristics of Galaxy clusters, and gravitational lensing.

In this module you will develop your skills in problem solving and research enquiry, communication, information searching, conceptualisation, and autonomy.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Quantum Optics and Information Theory
Module code: 6PAM1059 Semester: B Credits: 15

Module Aims:
The aims of this module are to enable students to understand the theoretical description of quantum systems, the quantization of the radiation field and atom–field interactions. Aspects of entanglement and quantum information theory are also introduced. Students will engage with the theoretical material mainly through guided computer algebra based experimentation. They will also carry out analytical work and background research.

Intended Learning Outcomes:
Successful students will typically:
- understand harmonic oscillator states and field quantisation;
- understand time dependent perturbation theory as applied to light–atom interactions;
- be able to research and analyse quantum optical experiments;
- understand aspects entanglement and information theory.

Successful students will typically:
- be able to apply creation and annihilation operator formalism to solve problems in quantum optics;
- be able to apply time dependent perturbation theory to solve problems on light–atom interactions;
- be able to use a computational algebra package to solve problems.

Module Content:
Quantum optics and modern quantum optical experiments have played a central role in the conceptual understanding of quantum mechanics and in its modern applications. This module will provide you with a basic theoretical understanding of quantum optics, computational skills for problem solving, and the opportunity to research the topics under study. Coverage will include the quantisation of the radiation field, optical tests of quantum mechanics, the emission and absorption of radiation by atoms, and aspects of quantum entanglement and quantum information theory.

The module develops skills in research enquiry and problem solving, analysis and evaluation, scientific writing and information searching.

Pre and Co requisites:

Pre requisite: Quantum Mechanics

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Lagrangian Dynamics

Module code: 6PAM1061 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to understand and work with the powerful formalisms of Lagrangian and Hamiltonian dynamics, beginning with the calculus of variations and introducing the ideas of Action, Lagrangian, Hamiltonian, Poisson brackets, and finally the geometry of phase space.

Intended Learning Outcomes:

Successful students will typically:

- understand of the calculus of variations;
- be able to explain and apply Lagrangian mechanics;
- have knowledge of Hamiltonian mechanics and phase space.

Successful students will typically:

- be able to derive the Euler−Lagrange equations and to use them to solve problems in the calculus of variations;
- be able to compute the Lagrangian of simple dynamical systems;
- be able to identify cyclic coordinates and their corresponding conservation laws;
- be able to pass between the Lagrangian and Hamiltonian formalisms in concrete examples;
- be able to conceptualise and identify important radiative processes;
- be able to manipulate Poisson brackets and perform computations involving the equations of motion on phase space.

Module Content:

This module introduces the powerful mathematics used in the study of dynamical systems. We start with the calculus of variations, a topic which deals with "extremisation" questions in geometry, e.g. "What shape does a soap−film form?", or "What curve is formed by a heavy chain hanging under its own weight?". These techniques can be applied to mechanical systems, and it turns out that the laws of motion themselves arise from extremising some quantity — the "action". This Lagrangian perspective gives a powerful way to compute a system's equations of motion and to understand its symmetries. Finally the module describes how the Hamiltonian formalism reduces these second order equations to first−order, and in so doing introduces the concept of phase space while touching on the rich topic of symplectic geometry. The module develops skills in research enquiry and problem solving, analysis and evaluation, and conceptualisation and critical thinking.

Pre and Co requisites:
Pre requisite: Multivariable Calculus 5PAM2012

Total hours: 150

Assessment:

Exam	Coursework	Practical
80%	20%	0%

Module name: Applied Phototonics

Module code: 6PAM2003 Semester: A Credits: 15

Module Aims:
The aims of this module are to enable students to gain knowledge and understanding at an advanced undergraduate level of the theory of optical and near−infrared image formation and quality under the paradigms of geometric optics (both paraxial and aberrated analyses) and physical optics (including the effects of diffraction, the modulation transfer function, Fourier optics and sampling). It also aims to teach students about modern applications of optics and photonics including sources of incoherent and coherent radiation, detectors and their characteristics, partially−transmitting components, research−level optical and photonic instruments, and non−linear optics theory and its applications.

Intended Learning Outcomes:
Successful students will typically:

- be able to derive paraxial geometric optics image formation equations and apply them to analyse and design multi−lens optical and near−infrared systems;
- be able to describe and calculate mathematically how real optical systems are distinguished from the paraxial paradigm in terms of aberration formation and the impact of the wave nature of light (physical optics), and evaluate the effects of aberrations and physical−optics considerations on image quality;
- be able to describe the characteristics of modern sources and detectors of optical and near−infrared radiation, and evaluate the pros and cons of different optical components for different applications.

Successful students will typically:

- be able to calculate and explain the imaging properties of a multi−lens optical system under the paraxial paradigm, evaluate likely aberrations, and describe appropriate steps to control aberrations;
- be able to select and configure appropriate sources and detectors of optical and near−infrared radiation and related optical components to accomplish specified tasks;
- be able to demonstrate proficiency in undertaking advanced laboratory work investigating optical principles and utilising modern photonic instruments.

Module Content:

Photonics is an important, modern high−tech industry with applications in optical communication, computing and information−storage, and medical imaging/detectors. Learn about photonics starting from image formation and aberrations, study lasers and other light emitting devices, and investigate current applications in photonics research fields, in lecture, laboratory and workshop settings.

In this module you will develop your skills in research enquiry and problem solving, analysis and evaluation, team and organisational working, interpersonal and communication skills.

Pre and Co requisites:

Pre requisites: Special Relativity and Quantum Physics (4PAM1066), The Physical Universe (4PAM1013), Optics and Lasers (5PAM1045) and Electromagnetism (5PAM1044)

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Groups and Representations

Module code: 6PAM2009 Semester: A Credits: 15

Module Aims:

The aims of this module are to enable students to understand concepts in representation theory of discrete and continuous groups and study their properties. It also aims at developing techniques for computing with them.

Intended Learning Outcomes:

Successful students will typically:

- Be able to demonstrate understanding of fundamentals of abstract group theory;
- Be able to use the key ideas of representation theory to study examples of finite groups and Lie groups/algebras.

Successful students will typically:

- Be able to construct irreducible representations for symmetric groups and some Lie algebras;
- Be able to classify irreducible representations using Young diagrams;
- Be able to compute tensor product representations of some Lie algebras.

Module Content:

Representation theory of groups plays an important role in abstract algebra as well as having important applications in other disciplines such as theoretical physics or crystallography. It provides a concrete way to study groups and their properties by representing them as a group of matrices, which is significantly more accessible than a generic group. This approach has been very fruitful in developing our understanding of groups over the last century and, among other applications, allowed for a proper description of elementary constituents of nature.

This module will provide a rigorous introduction to the main ideas and notions of groups and their representations, including representations of finite groups and Lie groups. It will also have a strong computational strand: a large part of the module will be devoted to explicit computations of representations and character tables.

Pre and Co requisites:
None

Total hours: 150

Assessment:

Exam	Coursework	Practical
60%	40%	0%

Module name: Mathematical Project and Investigative Skills
Module code: 6PAM2010 Semester: AB Credits: 30

Module Aims:
The aims of this module are to enable students to carry out a mathematics project, either in the form of a substantial literature review or consisting of a piece of research accompanied by a background review of the research topic. In either case the scope of the work should cover greater depth than is possible with other modules. It also aims to develop investigative skills, including initiative, independence, time management, communication, and writing/presenting skills.

Intended Learning Outcomes:
Successful students will typically:

- be able to acquire a strong knowledge and understanding of a research topic in mathematics or financial mathematics;
- be able to review the scientific literature effectively;
- be able to implement a piece of research and/or a literature review on a research topic in mathematics or financial mathematics.

Successful students will typically:

- be able to organise and plan a substantial literature review or research project;
- be able to implement an effective literature review for a research topic;
- be able to structure and produce a substantial science report;
- be able to present their work and debate points of interest in a viva style setting;
- be able to acknowledge all source material through adequate citation and demonstrate good academic integrity.

Module Content:

Students will carry out a piece of research and/or a literature review in a research topic. Astrophysics research areas in the School include; algebra, representation theory, financial mathematics, and mathematical and theoretical physics. A successful project will become a feature of a student's professional profile and CV, and is often a talking point in graduate job interviews and/or postgraduate applications.

The module develops skills in research enquiry and problem solving, analysis and evaluation, organisational working, interpersonal and communication skills, scientific writing and information searching, conceptualisation and critical thinking, adaptation to context, synthesis and creativity, personal evaluation and development, and ethical awareness and application.

Pre and Co requisites:

None

Total hours: 300

Assessment:

Exam	Coursework	Practical
0%	100%	0%