UNIVERSITY OF WOLVERHAMPTON

BSC (HONS) APPLIED PHYSICS

WHAT MAKES THE **STUDY** OF **PHYSICS** INTERESTING?

Physics explains natural phenomena in the universe, and so it is often considered to be the most fundamental science. It combines exploration, experimentation, intuition and formalization. These inquisitive qualities are more important than the subjects they study or describe: from optical phenomena of sunlight bouncing around or mechanical gears in a motor, to the dynamics of fluids in pipes, flocks of birds or the shape of a ponytail.

A physicist is someone who wants to figure things out by matching empirical observations, using simulations with computer codes, simple models based on a mathematical idea, trial-and-error, systematic laboratory experimentation or, more often than not, sheer luck! While every physicist has their favoured approach, breakthroughs come from combinations of these and a university course in Physics teaches them all so that students with an insatiable curiosity and enthusiasm can find fulfilment and capitalise on their potential.

This multifaceted and many-sided discipline makes it extremely entertaining as well as serious, demanding engagement and dedication. Following physicist David Deutsch's law: *"every problem that is interesting is also soluble"*, there is no failure in physics, only more understanding in a boundless universe of problems: *"In the long run, the distinction between what is interesting and what is boring is not a matter of subjective taste but an objective fact."*

Physics is a science for people who want to engage in societal issues and strive for progress. The impact of physics in our daily lives is visible in light-sources like LEDs and lasers, as well as the media to transport them (optical fibres); x-ray diffraction resulting in the discovery of DNA's structure; microwave technology of Wi-Fi, mobile phones and satnav systems; as well as the observation, exploration and rocketry of deep space exploration – all bear the imprint of physicists.

If you like to think, guess, bet, tweak, explore, discover and want to contribute to tomorrow's new and emerging technologies, the Applied Physics course is a good place to be.

WHAT ARE THE CAREER PROSPECTS FROM A COURSE IN PHYSICS?

Physics overlaps with many other disciplines: mathematics, engineering, computer science, chemistry, and increasingly, biology and medicine. Studying physics at university-level will bring you into contact with a wide variety of topics, providing much flexibility and a great panel of competencies for the world of work.

There are countless careers open to physicists, including: research science, academia (including teaching), engineering, manufacturing (dealing with computers, electronics, medical equipment), jobs related to medical technologies, radiology, scientific publishing, telecomunications, for example.

Applied physics focuses on all fields that have a potential for technology. As such it offers great professional prospects given the huge demand in this sector. Since the main quality of physicists is their great versatility, they also have proven to be extremely competitive and highly sought after even in positions extremely remote from their academic formation, such as in management, financing and trading. Physicists are also popular as system developers, investment analysts, operational researchers or patent attorneys.

ENTRY REQUIREMENTS

A minimum of BBC grades from at least two A2 levels (or equivalent), including study and pass grades in Physics and Mathematics at A2 level.

Access to HE Diploma gaining 60 credits in total with at least 45 credits achieved at level 3, (36 credits must be in science based units at level 3, including passes in Physics units: at least 27 of these 36 credits must be achieved at Merit or above and 9 credits with Pass or above).

GCSE English language and Mathematics at grade C or equivalent.

CONTENT OF THE COURSE

Your studies at University level combine a mixture of theory and practicals. You will develop self-study skills, critical analysis, literature research and produce personal reports on specific topics.

YEAR 1

OPTICS

An introduction to the science of light. Since our most privileged human contact with the surrounding world is through the eye, optics has always been a central topic in the description of the observable universe. You will study two aspects of light in depth: rays (geometrical optics) and waves (physical optics).

You will study how light rays form images in different scenarios using a range of optical devices to gain an understanding of microscopes, telescopes, eyeglasses, etc. and how deviations can be due to polarization, interferences and diffraction. Elements of photonics with the physics of lasers, optical detectors, waveguides, fibres and devices for imaging, display and storage will also be explored.

MECHANICS

An introduction to the science of matter and how it responds to applied forces. Mechanics is the epitome of physics: it describes and explains the behaviour of physical objects around us, from falling apples to orbiting planets, that are described by the same law (of universal gravitation).

The module will concentrate on Newtonian physics as an introduction to the methods and thinking of a physicist. Expanding on this classical material to introduce more advanced ideas and concepts of mechanics, including Einstein's special theory of relativity, you will be introduced to some elements of fluid mechanics and Lagrangian mechanics.

MATHEMATICAL METHODS 1

Carrying on the mathematics you studied before University, with a focus on the aspects of mathematics most needed by physicists. After refreshing your previous knowledge, in particular of elementary calculus (of real and complex numbers), you will move on to study real analysis (functions of one variable, trigonometry, series and limits) and gain a solid working knowledge of integration and derivation.

The bulk of the module will be on the theory of ordinary differential equations and linear algebra. Some basic elements of probabilities will also be provided.

ELECTROMAGNETISM 1

You will make your first contact with the greatest scientific achievement of the 19^{th} century, the unification of electricity and magnetism by Maxwell. Focusing on these two separate aspects, you will gain expertise with these important subfields to study the physics of electric charges and of magnets.

You will gain a solid background in the calculus of vector fields and in handling differential equations. Special emphasis will be given to electronic circuits as an applied illustration of important concepts of electrodynamics, and to support the laboratory sessions that will focus on these aspects.

QUANTUM MECHANICS

You will make your first contact with the greatest revolution in science, that turned everything else (including relativity that redefines our understanding of time and space) into "classical physics".

You will deal with Schrödinger equation and learn how microscopic objects behave according to our most current understanding of matter, involving counter-intuitive effects such as quantum tunnelling (crossing a barrier without having the potential energy to do so) or nonlocality (two particles being connected even when separated by distances preventing any force to link them). You will learn the implications for nanotechnologies and other technological prospects.

COMPUTING SKILLS

You will be endowed with the skills to turn a home computer into an extremely powerful, yet readily available, resource. Intensively based laboratory sessions and practical work will teach the necessary programming expertise.

To provide you from the start with modern and professional tools, you will be taught in the Python programming language, which is a high-level language, easy to learn and affording great code readibility and interactivity through ipython and Jupyter, that encourage exploration and on-the-fly design. The module will focus on numerical methods relevant for linear algebra and to solve simple equations that arise in many physical problems.

YEAR 2

ELECTROMAGNETISM II

Building on the first year module, you will deal with Maxwell's equations that show how electric and magnetic fields are interconnected and how light arises from one oscillating into the other and back. You will link the speed of light to elementary constants. You will learn about charge distributions and multipolar expansions, and re-approach Optics from this more modern and fundamental viewpoint and study phenomena such as radiation, propagation and interaction of waves with matter.

SOLID STATE PHYSICS

Building on your knowledge so far, you will see how general principles of mechanics and optics applied to more complex systems, such as collections of atoms, describing a solid, lead to a rich and accurate description of most of their behaviour, such as their classification as metals or insulators, semiconductors or dielectrics.

You will learn about crystals and how sound and electric charges propagate in them, and become familiar with important concepts such as Fermi gas and energy bands. The module will conclude with an introduction to material aspects through examples such as diamagnetism, ferroelectricity and superconductivity.

MATHEMATICAL METHODS 2

As your knowledge and depth of description of the physical phenomena mature, you will learn the correspondingly required mathematical tools, and be able to study functions of several variables and their associated partial differential equations, learn about dynamical systems, and study complex analysis, thereby revisiting most of your mathematical knowledge so far through the considerably more powerful and, unexpectedly, easier framework of complex numbers.

THERMODYNAMICS AND STATISTICAL PHYSICS

You will learn how the concept of statistics affects physics by studying (in the case of mechanics) how the behaviour of a complex system made up of a huge number of components (such as a gas made up of countless molecules) can be reduced thanks to probabilistic considerations to very few key variables, emerging from the microscopic interactions.

You will learn how this articulates the notions of heat and work, learn about entropy, that quantifies order and information, the laws of thermodynamics and the use of thermodynamic potentials, and be introduced to statistical ensembles, ergodicity and various notions of equilibrium.

QUANTUM PHYSICS

Deepening your knowledge of the quantum theory to describe more complex scenarios, you will revisit your first year knowledge in 3D geometries, that brings in the physics of quantum angular momentum and spin. The Heisenberg formalism will be introduced and the first formal connection will be made between particles and fields. The quantum aspects of the other disciplines will also be studied, such as quantum statistics or quantization in solids (phonons, Einstein solid). You will also learn the useful methods of perturbation theory and the variational principle.

NUMERICAL METHODS

In parallel to your strengthening mathematical skills, you will learn the corresponding numerical methods to implement them on the computer, and describe more complex physical phenomena such as those involving fields or time varying problems.

You will learn in particular about algorithms to solve differential equations and study in detail the family of Runge-Kutta methods, with emphasis on notions such as stability and convergence. You will also start to work on research-type problems involving your own analysis and exploration of a broadly defined generic problem of applied physics.

PHYSICS SANDWICH PLACEMENT

The physics sandwich placement provides an opportunity for professional development in the workplace and as such, greatly enhances the prospects for a student to find rewarding employment at the end of the course. Placements can be in industry, research or an educational institution.

YEAR 3

CONDENSED MATTER PHYSICS

You will learn about our contemporary understanding of the various forms of matter, based on bringing together quantum mechanics, electromagnetism and statistical physics.

Beyond the familiar phases of matter (gas, liquid and solid), you will learn about plasmas, Bose condensates, superfluids and superconductors and how they require new concepts for their description, such as symmetry breaking and phase transition in mean- and beyond mean-field theories. You will study experimental techniques to study materials through electric and magnetic fields, including light (spectroscopy), as well as their transport properties and thermometry.

ADVANCED MATHEMATICAL AND NUMERICAL METHODS

The mathematical and computational aspects of the physics course will be brought together in a single module to provide you with the sharpest tools required for the last year, before you are prepared to identify and forge your own depending on the problem at hand. Topics will include Fourier and Laplace analysis, variational calculus, Green functions, Optimization, Monte Carlo methods, theory of algorithms and some notion of complexity and information theory.

APPLIED PHYSICS

You will learn about the gems of physical engineering that led to our proudest technological achievements, including an advanced study of the laser and of the transistor, electronic engineering, amplifiers and parametric oscillators, optoelectronic devices, the study of semiconductor heterostructures and photonic crystals, thin films, plasmonic, metamaterials, spintronics and nuclear magnetic resonance.

QUANTUM ELECTRONICS AND ELECTRODYNAMICS

The module will first complete the classical exposition of the main themes of quantum physics with more advanced material such as time-dependent problems, WKB and adiabatic approximations, Berry phases, and will proceed with quantum effects in electronics and optics, introducing the basic notions of quantum field theory required to describe light-matter interactions at the quantum level. You will learn the current limitations of technology based on hitting the atomic barrier and study the possible trends for future progress.

RESEARCH TOPICS IN PHYSICS

Rewarding your efforts and building on your, by now extensive, knowledge of physics, you will be in a position to explore the latest areas of research. You will be introduced to a variety of original research topics, first through lectures and class discussion of recent relevant scientific publications, then through a personal research effort.

You will become aware of the professional issues in carrying out applied physics research. You will be accompanied by internationally recognized research-active academic and PhD students who will guide, advise and monitor your first steps in tackling a problem that has never been studied before.

THE UNIVERSITY OF OPPORTUNITY

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