School of Physics & Astronomy

Head of School

Professor A Miller

Degree Programmes

Single Honours Degrees:	Astrophysics (MSci) Physics (BSc & MSci) Physics with Electronics (MSci)† Physics with Photonics (MSci) Physics with Solid State Sciences (MSci) Theoretical Physics (MSci)
Joint Honours Degrees (BSc):	Physics and Chemistry, Computer Science, Mathematics, Logic & Philosophy of Science
Joint Honours Degree (MSci):	Theoretical Physics and Mathematics
Major Degree Programme (BSc)	Physics with Management

† Available only to students already enrolled in the Programme.

Programme Prerequisites - BSc and MSci

All BSc Degrees

11 or better in PH2001 and PH2002, and in MT2101 or (MT2001 and MT2003)

MSci Astrophysics

15 or better in AS2001, PH2001 and PH2002, and 11 or better in MT2101 or (MT2001 and MT2003)

MSci Physics, Physics with Electronics†, Physics with Photonics, Physics with Solid State Sciences

15 or better in PH2001 and PH2002, and 11 or better in MT2101 or (MT2001 and MT2003)

MSci Theoretical Physics

15 or better in PH2001 and PH2002, and in MT2101 or (MT2001 and MT2003)

MSci Theoretical Physics and Mathematics

15 or better in PH2001 and PH2002, and 17 or better in MT2101 or (MT2001 and MT2003)

Programme Requirements

Physics (BSc)

Single Honours degree: PH3001, PH3002, PH3007, PH3008, PH3012, PH3014, PH3026, and a further 135 credits from PH3001 - PH3103 and AS3001 - AS3103, subject to the conditions that (a) at least 15 credits must be selected from PH3101, PH3102, AS3101 and AS3102, and (b) one of PH3103 and AS3103 must be included.

Joint Honours degrees: PH3001, PH3007 and a further 90 credits from PH3001 - PH3102 and AS3001 - AS3006.

Physics with Management (BSc)

PH3001, PH3002, PH3007, PH3008, PH3012, PH3026, and between 60 and 90 further credits from PH3001 - PH3103 and AS3001 - AS3103, subject to the conditions that (a) at least 15 credits must be selected from PH3101, PH3102, AS3101 and AS3102, and (b) one of PH3103 and AS3103 must be included.

Astrophysics (MSci)

AS3001 - AS3004, AS3006, AS3101, AS3102, AS4001, AS4002, AS4101, PH3001, PH3007, PH3014, PH4009 and at least a further 60 credits from PH3001 - PH4099.

Physics (MSci)

PH3001, PH3002, PH3007, PH3008, PH3012, PH3014, PH3026, PH3101, PH3102, PH4009, PH4101 and at least a further 105 credits from PH3003 - PH4099 and AS3001 - AS4002 including at least 30 credits at 4000 level.

Physics with Electronics (MSci)†

PH3001 - PH3002, PH3004, PH3007, PH3008, PH3011, PH3012, PH3014, PH3026, PH3040 - PH3041, PH3101 - PH3102, PH4009, PH4101 and at least a further 45 credits from PH3003 - PH4099 and AS3001 - AS4002 including at least 30 credits at 4000 level.

Physics with Photonics (MSci)

PH3001 - PH3002, PH3005, PH3007, PH3008, PH3010, PH3012, PH3014, PH3026, PH3050, PH3101 - PH3102, PH4005, PH4008, PH4009, PH4101 and at least a further 30 credits from PH3003 - PH4099 and AS3001 - AS4002.

Physics with Solid State Sciences (MSci)

PH3001 - PH3002, PH3007 - PH3008, PH3012, PH3014, PH3026 - PH3027, PH3040, PH3050, PH3101 - PH3102, PH4001, PH4007, PH4009, PH4101 and a further 30 credits from PH3001 - PH4099 and AS3001 - AS4002.

Theoretical Physics (MSci)

PH3001 - PH3002, PH3007 - PH3009, PH3012 - PH3014, PH3026, MT3501, PH4002 - PH4003, PH4102, and a further 90 credits from PH3001 - PH4099 and AS3001 - AS4002 including at least 30 credits at 4000 level and including at least 15 credits from PH4004, PH4010 - PH4012..

Theoretical Physics and Mathematics (MSci)

PH3001, PH3007, PH3009, PH3012, PH4002 - PH4003, PH4102 or MT4500, and a further 45 credits from PH3001 - PH4099 and AS3001 - AS4002 including at least 30 credits from PH3026, PH3033, PH4004 and PH4010.

In the case of students who spend part of the Honours Programme abroad on a recognised Exchange Scheme, the Programme Requirements will be amended to take into account courses taken while abroad

Modules

AS1001 Astronomy and Astrophysics

Credits: 20.0 Semester: 1

Prerequisites: Higher Physics or A-level Physics or Higher Mathematics or A-level Mathematics.

Anti-requisite: AS1002

Description: This module surveys our present state of knowledge of the orbits, surfaces and atmospheres of the planets in our solar system; the structure and evolution of the Sun and other stars, including extra-solar planetary systems; the bizarre menagerie of star-forming regions, violent stellar objects and supermassive black holes found within our own Milky Way Galaxy and in other galaxies; and the large-scale structure and ultimate fate of the expanding Universe. Throughout the module, fundamental observations are interpreted using simple but powerful geometric methods to show how distances and other properties of astronomical objects throughout the Universe have been measured, from the time of Copernicus to the era of the Hubble Telescope and beyond.

Class Hour: 11.00 am

Teaching: Four lectures, one tutorial and one laboratory.

Assessment: Laboratory work = 25%, Continuous Assessment = 15%, 2 Hour Examination = 60%

Re-Assessment: Laboratory work = 25%, 2 Hour Examination = 75%

AS1002 The Physical Universe

Credits: 20.0 Semester: 2

Anti-requisites: AS1001 or PH1001 or PH1002 or PH1003

Description: This module presents a descriptive, non-mathematical account of the physical universe. It is divided into two components: concepts in astronomy, dealing with our understandings of the properties and ages of planets, stars, galaxies, and their distributions in space, cosmology and the origin of the Universe; and concepts in physics, dealing with our understandings of the nature of light and matter, the structure of atoms, fundamental particles and their links to cosmology.

Class Hour: 5.00 pm

Teaching: Three lectures, one tutorial/seminar.

Assessment: Continuous Assessment = 50%, 2 Hour Examination = 50%

Re-Assessment: 2 Hour Examination = 100%

PH1001 Physics 1A

Credits: 20.0 Semester: 1

Prerequisites: Higher Physics or A-level Physics and Higher Mathematics or A-level Mathematics.

Anti-requisite: AS1002

Description: This module covers the core subjects of mechanics, waves and optics, and the structure of matter, for students who have already studied these subjects at school or elsewhere. It includes lectures on the kinematics and dynamics of particles, gravitation and fluids; simple harmonic motion, transverse, longitudinal, travelling and standing waves, geometrical and wave optics; the atomic basis of matter, kinetic theory of gases, the condensed state, the nature of atoms, and elementary quantum concepts such as the photon.

Class Hour: 12.00 noon

Teaching: Four lectures, two tutorials and one laboratory.

Assessment: Laboratory work = 25%, Continuous Assessment = 15%, 2 Hour Examination = 60%

Re-Assessment: Laboratory work = 25%, 2 Hour Examination = 75%

PH1002 Physics 1B

Credits: 20.0 Semester: 2

Prerequisites: Higher or A-level Physics and Higher or A-level Mathematics.

Anti-requisite: AS1002

Description: This module completes the coverage at first year level of those branches of physics which (together with those in Physics 1A) form the core of the subject: electricity and magnetism, special relativity, thermal physics and quantum phenomena. It includes lectures on electric currents, magnetism and electric fields; the main kinematical and dynamical consequences of Einstein's postulates; temperature scales, the nature of heat, and heat flow processes; and an introduction to quantum physics including the wave function and the uncertainty principle.

Class Hour: 12.00 noon

Teaching: Four lectures, two tutorials and one laboratory.

Assessment: Laboratory work = 25%, Continuous Assessment = 15%, 2 Hour Examination = 60%

Re-Assessment: Laboratory work = 25%, 2 Hour Examination = 75%

PH1003 Physics Advances

Credits: 20.0 Semester: 2

Prerequisites: Higher Physics or A-level Physics.

Anti-requisite: AS1002

Description: The aim of this module is to provide brief but stimulating accounts of four of the most innovative branches of modern physics: lasers and optoelectronics, physics of materials, nuclear and particle physics and the general theory of relativity. The emphasis in each case will be on achieving an understanding of the concepts involved and the use of mathematics will be kept to a minimum.

Class Hour: 11.00 am

Teaching: Four lectures, one tutorial and one laboratory.

Assessment: Laboratory work = 25%, Continuous Assessment = 15%, 2 Hour Examination = 60%

Re-Assessment: Laboratory work = 25%, 2 Hour Examination = 75%

AS2001 Astronomy and Astrophysics

Credits: 30.0 Semester: 2

Prerequisites: PH1001, PH1002, MT1001 (or Higher Mathematics grade A together with CSYS Mathematics Paper 1 grade B, or A-level Mathematics grade C), MT1002 and AS1001.

Description: This module comprises four lecture courses which extend knowledge gained in the first level module AS1001, and discuss recent developments in the subject: (i) observational techniques - modern telescopes, instruments and detectors for gamma-, X-, uv, optical, IR and radio radiation; spherical astronomy and essential coordinate systems; (ii) the structure and evolution of stars - nucleosynthesis, stellar properties as a function of age, a complete understanding of the HR diagram; (iii) the chemical evolution of the Universe - abundances from the Big Bang to the present; (iv) galactic astronomy - the distribution and motion of stars, gas, dust, and dark matter in our Milky Way and other galaxies.

Class Hour: 11.00 am

Teaching: Four lectures, one tutorial and one laboratory.

Assessment: Laboratory work = 25%, Continuous Assessment = 15%, 3 Hour Examination = 60%

Re-Assessment: Laboratory work = 25%, 3 Hour Examination = 75%

PH2001 Physics 2A

Credits: 30.0 Semester: 1

Prerequisites: PH1001, PH1002, MT1001 (or Higher Mathematics grade A together with CSYS Mathematics Paper 1 grade B, or A-level Mathematics grade C), and MT1002.

Description: This module covers (i) quantum waves - the Schrodinger wave equation, and the solution of the energy eigenvalue equation for simple potentials in one dimension; (ii) mechanics - central force problems, the motion of rigid bodies, non-inertial frames of reference; (iii) electricity and magnetism - a more mathematical treatment than in the first year course, with more emphasis on vectors and continuous media, and (iv) optics - an introduction to matrix methods in geometrical optics, polarised light, and interference and diffraction.

Class Hour: 10.00 am

Teaching: Four lectures, one tutorial and one laboratory.

Assessment: Laboratory work = 25%, Continuous Assessment = 15%, 3 Hour Examination = 60%

Re-Assessment: Laboratory work = 25%, 3 Hour Examination = 75%

PH2002 Physics 2B

Credits: 30.0 Semester: 2

Prerequisites: PH1001, PH1002, MT1001 (or Higher Mathematics grade A together with CSYS Mathematics Paper 1 grade B, or A-level Mathematics grade C), and MT1002.

Description: This module covers (i) special relativity - the Lorentz transformation equations and their consequences, and relativistic dynamics; (ii) atoms, molecules and solids - the Bohr model of the atom, and multi-atom physics; (iii) circuit theory and electronics - an analysis of digital and analogue devices; and (iv) kinetic theory - the Maxwell velocity distribution, mean free path, viscosity, diffusion and thermal conductivity.

Class Hour: 10.00 am

Teaching: Four lectures, one tutorial and one laboratory.

Assessment: Laboratory work = 25%, Continuous Assessment = 15%, 3 Hour Examination = 60%

Re-Assessment: Laboratory work = 25%, 3 Hour Examination = 75%

The prerequisite for each of the following Honours modules is entry to the Honours

Programme(s) for which they are specified, save where a specific prerequisite is given.

AS3001 Modern Optical Instrumentation

Credits: 15.0 Semester: 2

Antirequisite: PH3010

Description: The course shows how a basic knowledge of physics, particularly optics, can be applied to our understanding of several important areas of modern optical instrumentation. Topics include: imaging systems at the diffraction limit; the plane diffraction grating: optical properties, manufacture and use in spectrographs; the photomultiplier detector and its use for photon counting; the CCD detector: construction, properties and operation as a low-light level detector; proximity image intensifiers; micro-channel plates and their incorporation into image intensifiers; active and adaptive optics; fibre-optic feeds; the Fabry-Perot interferometer: theory, use for laboratory spectroscopy and its use in astronomy; the determination of mirror optical figures.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

AS3002 Astrophysical Processes

Credits: 15.0 Semester: 1

Prerequisite: AS2001

Description: This module introduces the physics of astrophysical plasmas, as found in stars and interstellar space, where interactions between matter and radiation play a dominant role. A variety of absorption, emission, and scattering processes are introduced to describe exchanges of energy and momentum, which link up in various contexts to control the state and motion of the matter, to regulate the flow of light through the matter, and to impress fingerprints on the emerging spectrum. The theory is developed in sufficient detail to illustrate how astronomers interpret observed spectra to infer physical properties of astrophysical plasmas. Applications are considered to photo-ionized nebulae, interstellar shocks, nova and supernova shells, accretion disks, quasar absorption line clouds, radio synchrotron jets, radio pulsars, and X-ray plasmas.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

AS3003 Stellar Physics

Credits: 15.0 Semester: 2

Prerequisite: AS3002

Description: This module develops the physics of stellar interiors and atmospheres from the basic equations of stellar structure introduced in AS2001. Topics include: the equation of state that provides pressure support at the high temperatures and densities found in normal and white-dwarf stars; the interaction of radiation with matter, both in terms of radiation-pressure support in super-massive stars and in terms of the role of opacity in controlling the flow of energy from the stellar interior to the surface; the equation of radiative transfer and the effects of local temperatures, pressures and velocity fields on the continuum and line absorption profiles in the emergent optical spectrum. Computer-aided tutorial exercises illustrate the computational schemes that represent one of the triumphs of late 20th-century physics, in their ability to predict the observable properties of a star from its radius and luminosity, which in turn are determined by its mass, age and chemical composition.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

AS3004 Stellar Dynamics

Credits: 15.0 Semester: 1

Prerequisite: AS2001

Description: The syllabus for this module includes: brief review of two-body motion; application to binary systems of stars observed with various techniques (velocities, pulsar-timing); extension to n-body systems of point-masses and use of virial theorem; gravitational potentials resulting from non-spherical masses, with application to tidal phenomena on the Earth and on stars, and resulting from distribution of point-masses over large distances, with application to the observed structure of galaxies; numerical methods for calculating orbits. The statistical treatment of large numbers of self-gravitating masses; the collisionless Boltzmann equation and its application to determining the masses of galaxies and clusters of galaxies; the 'dark matter' problem.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

AS3006 Galaxies and Observational Cosmology

Credits: 15.0 Semester: 2

Prerequisite: AS2001

Description: This module provides a general overview of the properties of galaxies and shows the empirical evidence that leads to the conclusion that our Universe is expanding. How measurements are made of distances, the local rate of expansion and the local mass density are explained. The standard Big Bang model is then developed starting from Olber's Paradox ("Why is the sky dark at night?") and showing how the rate of expansion is dependent on the amount of matter, radiation and vacuum energy within the Universe. This includes due consideration of expanding curved geometries (or spacetime) and a discussion of the success and problems with the current model. The module culminates in an estimation of the current age of our Universe and its ultimate fate based on the latest observational evidence.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

AS3101 Astrophysics Laboratory 1

Credits: 15.0 Semester: 1

Prerequisite: AS2001

Description: The aim of the module is to familiarise students with a wide range of problems and techniques in astronomy and astrophysics, while allowing them to pursue individual interests. Students gain experience in the application of many transferable skills including: observation, measurement; data analysis; computer programming and modelling; and report writing. Students are required to tackle four units of practical work, each lasting about twelve hours, covering principles of astronomical observation, astrometry, photometry, stellar spectroscopy and theoretical astrophysics.

Class Hour: 2.00 - 5.00 pm Monday and 2.00 - 5.00 pm Thursday.

Teaching: Two laboratories.

Assessment: Continuous Assessment = 100%

AS3102 Astrophysics Laboratory 2

Credits: 15.0 Semester: 2

Prerequisite: AS2001

Description: The aim of the module is to familiarise students with a wide range of problems and techniques in astronomy and astrophysics, while allowing them to pursue individual interests. Students gain experience in the application of many transferable skills including: observation, measurement; data analysis; computer programming and modelling; and report writing. Students are required to tackle four units of practical work, each lasting about twelve hours, covering principles of astronomical observation, astrometry, photometry, stellar and theoretical astrophysics.

Class Hour: 2.00 - 5.00 pm Monday and 2.00 pm - 5.00 pm Thursday.

Teaching: Two laboratories.

Assessment: Continuous Assessment = 100%

AS3103 Project in Astrophysics 1

Credits: 30.0 Semester: Whole Year

Description: The project aims to develop students' skills in searching the appropriate literature, in experimental and observational design, the evaluation and interpretation of data, and the presentation of a report. The main project is preceded by a review essay. There is no specific syllabus for this module. Students taking the BSc degree select a project from a list of those which are available, and are supervised by a member of the academic staff.

Assessment: Project and Oral Examination = 100%

PH3001 Quantum Mechanics 1

Credits: 15.0 Semester: 1

Description: This module discusses the main principles of quantum mechanics and some of its most important applications. The syllabus includes: early ideas on quantisation, and the emergence of the Schrodinger equation; the interpretation of the wave function; Heisenberg's uncertainty relations; simple one-dimensional problems including potential barriers and wells; the linear harmonic oscillator; representation of physical variables by operators, and the significance of their eigenvalues; the solution of the Schrodinger equation for central forces, Legendre polynomials and spherical harmonics; the radial Schrodinger equation; the hydrogen atom; approximate methods; the variational principle, and time-independent perturbation theory. Students are introduced to computer simulations of one-dimensional problems, and are required to carry out computer-based exercises and a small project.

Class Hour: 10.00 am, Monday, Tuesday and Thursday.

Teaching: 23 lectures, 6 tutorials, and 2 sessions in the PC classroom.

Assessment: Continuous Assessment = 20%, 2 Hour Examination = 80%

PH3002 Solid State Physics 1

Credits: 15.0 Semester: 1

Description: This introductory course is intended to show how the various optical, thermal and electrical properties of solids are related to the nature and arrangement of the constituent atoms in a solid. For simplicity, emphasis is given to crystalline solids. The module examines: symmetry properties of crystals; common crystalline structures; the behaviour of waves in crystals; waves of atomic motion, leading to thermal properties; electronic energy states: conductors, insulators, semiconductors; electrical properties arising from the wave nature of electrons; examples of the fundamental theory to typical solids such as simple metals, silicon and other semiconductors, and magnetic materials.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3004 Digital & Analogue Circuits I

Credits: 15.0 Semester: 1

Description: This course will introduce and develop the basic principles of the synthesis and analysis of digital and analogue circuits. It will advance students' knowledge of transistor circuits and introduce them to the structure and uses of microprocessors. It will cover: passive circuit elements, solution of circuits by differential equations and Laplace transforms; types of impulses, system functions and frequency responses; circuit synthesis; design of digital circuits - combinational, synchronous, asynchronous and pulse mode; internal structure of microprocessors, and memories and structure of microprocessor systems; unipolar and bipolar transistors, amplifiers and switches, types of amplifiers.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3005 Laser Physics 1

Credits: 15.0 Semester: 1

Description: This module presents a basic description of the main physical concepts upon which an understanding of laser materials, operations and applications can be based. Ths syllabus includes: basic concepts of energy-level manifolds in gain media, particularly in respect of population inversion and saturation effects; conditions for oscillator stability in laser resonator configurations and transverse and longitudinal cavity mode descriptions; single longitudinal mode operation for spectral purity and phase locking of longitudinal modes for the generation of periodic sequences of intense ultrashort pulses (i.e. laser modelocking); illustrations of line-narrowed and modelocked lasers and the origin and exploitability of intensity-induced nonlinear optical effects.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3007 Electromagnetism

Credits: 15.0 Semester: 2

Description: The properties of electric and magnetic fields will be discussed, starting with static fields and moving on to time-dependent properties. Maxwell's equations are derived, and result in the wave equation and the conclusion that light is an electromagnetic wave. The theory is applied to the transmission of waves in free space, ionised gases (plasmas), metals and dielectrics. The relation between electromagnetic theory and quantum theory will be discussed briefly.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3008 Atomic Physics

Credits: 15.0 Semester: 2

Prerequisite: PH3001

Description: This module provides a rational basis to the identification of atomic energy states and the various interactions of electrons within atoms. It provides an understanding of aspects of laser physics, solid state and stellar physics. The syllabus includes: electron cloud model of an atom; electron spin; magnetic moments of electron behaviour; spin-orbit interactions and possible states of electron energy; one and two-electron systems; line intensities; Lande g-factors; weak Zeeman and strong Paschen-Back magnetic field effects; stark electric field effects; hyperfine structure and Lamb shifts; magnetic resonance and esr in atomic beam experiments; molecular structure: electronic, vibrational and rotational effects.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3009 Quantum Mechanics 2

Credits: 15.0 Semester: 2

Prerequisite: PH3001

Description: The aim is to extend the theory of quantum mechanics to include many-particle systems and time-dependent states with application to atomic physics. The syllabus includes: wave functions for many-particle systems, the Pauli principle and exchange interactions; the time evolution of a system, and transitions between quantum states; operator methods applied to the harmonic oscillator and angular momentum; application to atomic states, to include spin-orbit interactions, relativistic corrections and selection rules. The main features of the periodic table and the spectra of the alkali atoms will be explained in terms of the Hartree model.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3010 Modern Optics

Credits: 15.0 Semester: 2

Antirequisite: AS3001

Description: This course formulates the main aspects of physics used in modern optics, lasers and optoelectronic systems. Topics covered include: polarised light and its manipulation, with descriptions in terms of Jones' vectors and matrices; Fresnel's equations for transmittance and reflectance at plane dielectric interfaces; reflection and transmission of multi-layer thin films plus their use in interference filters; interpretation of diffraction patterns in terms of Fourier theory; spatial filters; the theory and use of Fabry-Perot etalons; laser cavities and Gaussian beams.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3011 Information and Measurement

Credits: 15.0 Semester: 2

Description: The course explains what information is, how we process it, and how it is collected by making measurements. The first eight lectures concentrate on the basics of measurement, information theory, and processing systems. The rest of the course uses various examples to show how these basics are put into use. The CD system is used to illustrate information collection, processing, and communication in digital form. Data compression/reduction is illustrated with examples which include digital compact cassette. Other illustrations include the methods used by spies to encrypt messages and the applications of chaotic systems and signals.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3012 Thermal and Statistical Physics

Credits: 15.0 Semester: 1

Description: The aim of this module is to cover at honours level the principles and most important applications of thermodynamics and statistical mechanics. The syllabus includes: derivation of the three laws of thermodynamics, and the equation of state; Maxwell's relations; correction of solid state results from constant pressure to constant volume, liquifaction of gases; concept of independent quantum state; energy levels and degeneracy; the microcanonical ensemble; quantum gases and the classical limit; the canonical ensemble; fluctuations; the connection with thermodynamics; the classical perfect gas; equipartition of energy; the grand canonical ensemble; black body radiation; matter at high density and pressure; fluctuations and noise; phase transitions; negative temperatures.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3013 Introduction to Theoretical Physics

Credits: 15.0 Semester: 1

Description: The first part of this module introduces techniques for solving problems in mechanics that go beyond simple methods employing Newton's laws. Two approaches are developed, both of which involve expressing the energy of the system in terms of its generalised coordinates together with its generalised velocities (the Lagrange method) or generalised momenta (the method of Hamilton). The second part deals with elementary tensor theory and its application to special relativity. The third part covers series solutions to differential equations of second order, with specific application to Hermite polynomials, Legendre polynomials and spherical harmonics. A few lectures on the Dirac delta function are also included.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3014 Transferable Skills for Physicists

Credits: 15.0 Semester: Whole Year

Prerequisites: PH2001 and PH2002

Description: The aim of the module is to develop the key skills of oral and written communication, information technology, team working and problem solving. This will be done in the context of physics and astronomy. Guidance, practice and assessment will be provided in the preparation and delivery of talks, critical reading of the literature, report and essay writing, programming to solve physical problems, developing and writing a case for resources to be expended to investigate a particular area of science, tackling case studies.

Class Hour: To be arranged.

Teaching: 4 lectures and 23 tutorial/workshop hours.

Assessment: Continous Assessment on basis of exercises = 100%

PH3026 Nuclear and Particle Physics

Credits: 15.0 Semester: 2

Description: The aim of this module is to describe in terms of appropriate models, the structure and properties of the atomic nucleus, the classification of fundamental particles and the means by which they interact. The syllabus includes: nuclear sizes, binding energy, spin dependence of the strong nuclear force; radioactivity, the semi-empirical mass formula; nuclear stability, the shell model, magic numbers; spin-orbit coupling; energetics of ß-decay, α-decay and spontaneous fission; nuclear reactions, resonances; fission; electroweak and colour interactions, classification of particles as intermediate bosons, leptons or hadrons. Standard model of leptons and quarks, and ideas that go beyond the standard model.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3027 Magnetism and Superconductivity

Credits: 15.0 Semester: 1

Prerequisites: PH3001, PH3002, PH3007

Description: The module presents a range of magnetic phenomena in solids, develops the theoretical models for them and explains how the chemical features and structure of real materials influence the magnetic properties. The syllabus includes: review of magnetic field vectors, magnetisation, shape effects; superconductivity, phase diagrams, thermodynamic and London models; coherence length, surface energies, type I and II materials; quantised flux and fluxoid lattice; bean model, BCS theory, macroscopic quantum effects, Josephson tunnelling; modern superconducting materials, Langevin diamagnetism, local moment paramagnetism; mean field models, exchange, direct and indirect, and RKKY interactions; magnetic order; delocalised model, Landau diamagnetism, Pauli paramagnetism, Stoner model, spin waves; materials - rare earth, transition elements, alloys and compounds; domains; examples of current problems in magnetism.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3039 Computational Physics

Credits: 15.0 Semester: 2

Description: The aim of this module is to introduce students to the use of the computer as an analytical tool in physics and astronomy. The module comprises: (i) an introduction to programming in a high-level language including editing, structured programming and the essentials of the language required to program for scientific application; (ii) the application of Mathcad to problems involving matrices and tensors, differential equations, Fourier transforms and Monte Carlo methods; (iii) the application of computational methods to scientific problem solving.

Class Hour: To be arranged.

Teaching: Two lectures each week and two 1 hour laboratories.

Assessment: Continuous Assessment on basis of projects = 100%

PH3040 Physics of Electronic Devices

Credits: 15.0 Semester: 2

Description: The course describes the physical phenomena involved in the operation of semiconductor devices, and then shows how the phenomena determine the properties of specific devices such as the transistor. Although only a few devices are described, the student taking the course should acquire a sufficient background to understand a wide variety of modern semiconductor devices. The course covers: semiconductor properties: band gaps, optical and electrical properties; conduction in an electric field and by diffusion; factors determining the concentrations of electrons and holes; the continuity equation; properties of pn junctions and Schottky diodes; typical devices: bipolar transistor, field-effect transistor, MOSFET, light emitting diodes, semiconductor lasers.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3041 Radio and Coherent Techniques

Credits: 15.0 Semester: 1

Description: The aim of this course is to explain the techniques used by radio, microwave and mm-wave engineers to communicate, and collect, information. It concentrates mainly upon radio techniques to explain how coherent electromagnetic signals can be employed to carry information. Practical examples are given to illustrate the way the basic concepts can be applied. These include an explanation of how FM stereo radio and colour TV work as examples of signal multiplexing. The course looks at microwave and millimetre-wave techniques and shows how electronics and optics can be mixed at higher signal frequencies. Using the examples of spy and other types of satellites, it also explains how radar and passive sensing systems can be used to gather information.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3050 Optoelectronics and Nonlinear Optics 1

Credits: 15.0 Semester: 1

Prerequisite: PH3007

Description: The course provides an introduction to the basic physics underpinning optoelectronics and nonlinear optics, and a perspective on contemporary developments in the two fields. The syllabus includes: an overview of optoelectronic devices and systems; optical modulators; acousto-optics; Bragg and Raman-Nath; propagation of light in anisotropic media; electro-optics; waveguide and fibre optics; modes of planar guides; optical detectors-pn, pin, avalanche; nonlinear optics; active and passive processes in second and third order; second harmonic generation; phase matching; coupled wave equations; parametric oscillators; self-focusing and self-phase-modulation; optical bistability; phase conjugation; solitons; Rayleigh; Raman and Brillouin scattering.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH3101 Physics Laboratory 1

Credits: 15.0 Semester: 1

Description: The aims of the module are (i) to familiarise students with a wide variety of experimental techniques and equipment, and (ii) to instil an appreciation of the significance of experiments and their results. The module consists of four sub-modules on solid state physics, lasers, interfacing, and signal processing.

Class Hour: 2.00 - 5.00 pm Monday and 2.00 - 5.00 pm Thursday

Teaching: Two 3 hour laboratories.

Assessment: Continuous Assessment = 100%

PH3102 Physics Laboratory 2

Credits: 15.0 Semester: 2

Description: The aims of the module are (i) to familiarise students with a wide variety of experimental techniques and equipment, and (ii) to instil an appreciation of the significance of experiments and their results. Students select four sub-modules from a list comprising solid state physics, optics and spectroscopy, circuits and circuit simulations, microprocessors, lasers and vacuum techniques.

Class Hour: 2.00 - 5.00 pm Monday and 2.00 - 5.00 pm Thursday

Teaching: Two 3 hour laboratories.

Assessment: Continuous Assessment = 100%

PH3103 Project in Physics 1

Credits: 30.0 Semester: Whole Year

Prerequisites: At least one of PH3101, PH3102

Description: The project aims to develop students' skills in searching the physics literature and in experimental design, the evaluation and interpretation of data, and in the presentation of results. The main project is preceded by a review essay on a topic which may be related to the theme of the project or may be unrelated to it. There is no specific syllabus for this module. Students taking the BSc degree select a project from a list offered, and are supervised by a member of staff.

Assessment: Project and Oral Examination = 100%

The Prerequisite for each of the following 4000 modules is entry to the MSci Programme(s) for which they are specified, save where an additional prerequisite is given.

AS4001 Astronomical Data Analysis

Credits: 15.0 Semester: 1

Prerequisite:: AS2001

Description: This module develops an understanding of basic concepts and offers practical experience with the techniques of quantitative data analysis. Beginning with fundamental concepts of probability theory and random variables, practical techniques are developed for using quantitative observational data to answer questions and test hypotheses about models of the physical world. The methods are illustrated by applications to the analysis of time series, imaging, spectroscopy, and tomography datasets. Students develop their computer programming skills, acquire a data analysis toolkit, and gain practical experience by analyzing real datasets.

Class hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: Continuous Assessment = 100%

AS4002 Star Formation and Plasma Astrophysics

Credits: 15.0 Semester: 2

Prerequisite: AS2001

Description: The aim is to describe the physics of how a magnetic field interacts with a plasma, and to use this knowledge to explore the role of magnetic fields in the formation of solar-like stars and in compact objects with accretion discs. The syllabus comprises: Solar-like magnetic activity on other stars. The basic equations of magneto-hydrodynamics. Stellar coronae: X-ray properties and energetics of coronal loops. Energetics of magnetic field configurations. MHD waves and propagation of information. Solar and stellar dynamos: mean field models. Star formation: properties of magnetic cloud cores, magnetic support. Physics of accretion discs: transport of mass and angular momentum. Accretion on to compact objects and protostars. Rotation and magnetic fields in protostellar discs. Rotation distributions of young solar-type stars. Magnetic braking via a hot, magnetically channelled stellar wind.

Class hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour examination = 100%

AS4101 Project in Astrophysics 2

Credits: 45.0 Semester: Whole Year

Description: The project aims to develop students' skills in searching the appropriate literature, in experimental

and observational design, the evaluation and interpretation of data, and the presentation of a report. The main project is preceded by a review essay. There is no specific syllabus for this module. Students taking the MSci degree select a project from a list of those which are available, and are supervised by a member of the academic staff.

Assessment: Project and Oral Examinations = 100%

PH4001 Solid State Physics 2

Credits: 15.0 Semester: 1

Prerequisites: PH3001 and PH3002

Description: The aim of this module is to develop an understanding of band-structure in crystalline solids, Fermi surfaces in reciprocal space and the Boltzmann transport equation. It examines: reciprocal space concepts reviewed and extended; tight-binding theory for simple cubic structure; Kronig-Penney model; fermi surfaces in real structures; measurement techniques; Landau levels, Shubnikov-de Haas and de Haas-van Alphen experiments; Boltzmann transport of charge and thermal energy.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4002 Quantum Mechanics 3

Credits: 15.0 Semester: 2

Prerequisite: PH3009

Description: This is a course on the foundations of quantum mechanics. It consists of five parts: (i) Hilbert spaces and operators including a discussion of spectral decomposition of selfadjoint operators; (ii) postulates of quantum mechanics for observables with discrete spectra with illustrative examples including various pictures (Schrodinger, Heisenberg, interaction) of time evolution; (iii) postulates of quantum mechanics for observables with continuous spectra in terms of probability distribution functions and the spectral functions; (iv) quantum theory of orbital, spin angular momenta and their addition, Pauli-Schrodinger equation; (v) introduction to relativistic quantum mechanics.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4003 Group Theory

Credits: 15.0 Semester: 1

Prerequisite: PH3001

Description: This module explores the concept of a group, including groups of coordinate transformations in three-dimensional Euclidean space; the invariance group of the Hamiltonian operator; the structure of groups: subgroups, classes, cosets, factor groups, isomorphisms and homorphisms, direct product groups; introduction to Lie groups, including notions of connectness, compactness, and invariant integration; representation theory of groups, including similarity transformations, unitary representations, irreducible representations, characters, direct product representations, and the Wigner-Eckart theorem; applications to quantum mechanics, including calculation of energy eigenvalues and selection rules.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4004 Quantum Field Theory

Credits: 15.0 Semester: 2

Availability: 2001-02

Prerequisite: PH4002

Description: The syllabus for this module includes: second quantization for bosons and fermions; annihilation and creation operators; introduction to classical field theory, including the notion of Lagrangian and Hamiltonian densities; the real and complex Klein-Gordon fields for spin zero particles; the Dirac field for spin 1/2 particles; quantization of the electromagnetic field; perturbation expansion for the S matrix; Wick's theorem; origin and use of Feynman rules; outline of idea of renormalization; application to quantum electrodynamics.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4005 Laser Physics 2

Credits: 15.0 Semester: 2

Prerequisites: PH3001, PH3005 and PH3007

Description: Quantitative treatment of laser physics embracing both classical and semiclassical approaches; transient/dynamic behaviour of laser oscillators including relaxation oscillations, amplitude and phase modulation, frequency switching, Q-switching, cavity dumping and mode locking; design analysis of optically-pumped solid state lasers; laser amplifiers including continuous-wave, pulsed and regenerative amplification; dispersion and gain in a laser oscillator - role of the macroscopic polarisation; unstable optical resonators, geometric and diffraction treatments; quantum mechanical description of the gain medium; coherent processes including Rabi oscillations; semiclassical treatment of the laser; tunable lasers.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4007 Structures and Dynamics of Solids

Credits: 15.0 Semester: 2

Availability: 2001-02

Prerequisite: PH3002

Description: The aim is to develop an understanding of how and why condensed matter scientists attempt to determine the relative positions and motions of atoms in solids. The course will largely focus on neutron techniques, but the relevance of other scattering methods will also be discussed. The syllabus comprises: Introduction to the properties of the neutron and its interaction with matter. Neutron production and instrumentation. Determination of atomic and magnetic structures using neutron diffraction. Diffuse scattering studies of disordered materials, liquids and amorphous solids. The study of large scale macromolecular and biological structures, and of phase transitions, using small angle scattering. Isotopic techniques and contrast matching. Coherent and incoherent excitations in solids, and quasi-elastic scattering studies of tunnelling phenomena. The characterisation of surfaces using reflectometry. Polarised neutron methods.

Class hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4008 Optoelectronics and Nonlinear Optics 2

Credits: 15.0 Semester: 2

Prerequisite: PH3050

Description: This module develops concepts introduced in PH3050 to a level at which the student should

be able to understand state-of-the-art systems in these fields and to appreciate the research literature. In particular, the ideas of nonlinear optics are developed more quantitatively and in greater depth, and the course shows how such properties can be the basis of important devices. The field of optical communication is covered, include the modes of propagation in waveguides and the use of nonlinear effects in optical waveguides. Optoelectronic devices such as SEED are described, including their roles in optical switching.

Class hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour examination = 100%

PH4009 Advanced Mathematical Techniques in Physics

Credits: 15.0 Semester: 1

Description: The module aims to develop the more sophisticated mathematical techniques that form an appropriate part of the education of a professional physicist or astronomer. Starting from examples selected from various areas of physics, the module will develop enhanced mathematical tools for the efficient solution of problems in these areas. Analytic mathematical skills will be complemented by the development of computer-based solutions. The emphasis throughout will be on obtaining solutions to problems in physics and its applications. Specific topics to be covered will include tensor analysis, numerical analysis, probability theory and statistics, Fourier and Laplace transforms, operator techniques, selected functions and their properties, constrained optimisation, and nonlinear systems.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4010 Particle Symmetries

Credits: 15.0 Semester: 2

Prerequisites: PH3026, PH4003

Description: Group theoretical methods have been extremely successful in making predictions and bringing an ordered understanding to fundamental particles. This module in intended to treat two major developments, the su(3) theory of hadrons, including the development of the concept of quarks, and the concept of spontaneous symmetry breaking in both global and local gauge theories, leading to the unified gauge theory of weak and electromagnetic interactions and to quantum chromodynamics. Topics include: The concept of a Lie algebra, and its connection with the idea of a Lie group. Basic general properties of Lie algebras. The theory and classification of semi-simple Lie algebras. The su(3) theory of hadrons. Appearance of Goldstone bosons in spontaneous symmetry breaking of global models. Abelian and non-Abelian gauge theories. Higgs bosons. Unified gauge theory of weak and electromagnetic interactions. Quantum chromodynamics.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4011 General Relativity

Credits: 15.0 Semester: 2

Anti-requisite: PH3033

Description: This module examines: inertial frames, gravity, principle of equivalence, curvature of spacetime;

basic techniques of tensor analysis; Riemannian spaces, metric tensor, raising and lowering of indices, Christoffel symbols, locally flat coordinates, covariant derivatives, geodesics, curvature tensor, Ricci tensor, Einstein tensor; fundamental postulates of general relativity: spacetime, geodesics, field equations, laws of physics in curved spacetime; distances, time intervals, speeds; reduction of equations of general relativity to Newtonian gravitational equations; Schwarzschild exterior solution, planetary motion, bending of light rays, time delays; observational tests of general relativity; Schwarzschild interior solution, gravitational collapse, black holes.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4012 Quantum Optics

Credits: 15.0 Semester: 1

Prerequisite: PH3001

Description: Quantum optics is the theory of light that unifies wave and particle optics. Quantum optics describes modern high-precision experiments that often probe the very fundamentals of quantum mechanics. The module introduces the quantisation of light, the concept of single light modes, the various quantum states of light and their description in phase space. The module considers the quantum effects of simple optical instruments and analyses two important fundamental experiments: quantum-state tomography and simultaneous measurements of position and momentum.

Class Hour: To be arranged.

Teaching: 27 lectures and 6 tutorials.

Assessment: 2 Hour Examination = 100%

PH4101 Project in Physics 2

Credits: 45.0 Semester: Whole Year

Prerequisite: PH3101

Description: The project aims to develop students' skills in searching the physics literature and in experimental design, the evaluation and interpretation of data, and in the presentation of results. The main project is preceded by a review essay on a topic which may be related to the theme of the project or may be unrelated to it.There is no specific syllabus for this module. Students taking the MSci degree select a project from a list offered, and are supervised by a member of staff.

Assessment: Project and Oral Examination = 100%

PH4102 Project in Theoretical Physics 2

Credits: 30.0 Semester: Whole Year

Description: The project aims to survey the literature associated with the topic of the project and either (i) conduct original research into some problem in this field or (ii) prepare a research review of the field. In each case a written report is submitted in the range 5,000 to 10,000 words.There is no specific syllabus for this module. Students taking the MSci degree select a project from a list of those which are available, and are supervised by a member of the academic staff.

Assessment: Project and Oral Examination = 100%