Physics (PH) modules

PH3007 Electromagnetism

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	9.05 am Mon even numbered weeks, 9.05 Tue, Thu, 15.05 Fri odd-numbered weeks			
The properties of electromagnetic fields will be explored using a variety of mathematical tools (in particular, vector and differential calculus). Topics will include: charge and current distributions, electro- and magnetostatics, materials, electrodynamics, conservation principles, electromagnetic waves and radiation. This module builds on knowledge and skills acquired in prior coursework by developing techniques for solving more advanced problems in electromagnetism.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics, Physics and Chemistry, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	(PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)] and PH2012 and [MT2001 or (MT2501 and MT2503)].			
Required for:	PH4025, PH4027, PH4032, PH5005			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 35 hours		**Guided independent study:** 115 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 60%, Practical Examinations = 0%, Coursework = 40%			
	As used by St Andrews: 2-hour Written Examination = 60%, Coursework = 40%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr C Baily			
Lecturer(s)/Tutor(s):	Dr C Baily			

PH3012 Thermal and Statistical Physics

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	12.00 noon odd Mon, Wed, Fri, 2.00 pm even Tue			

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: equilibrium; the equation of state; the classical perfect gas; discussion of experimental results that lead to the three laws of thermodynamics; idealised reversible engines; the Clausius inequality; the classical concept of entropy and its connection to equilibrium; thermodynamic potentials; Maxwell's relations; open systems and the chemical potential; phase transitions and the Clausius-Clapeyron equation for first order transitions; higher order phase transitions; the connection between statistical physics and thermodynamics; the Boltzmann form for the entropy; microstates and macrostates; the statistics of distinguishable particles; the Boltzmann distribution; the partition function; statistical definition of the entropy and Helmholtz free energy; statistical mechanics of two-level systems; energy levels and degeneracy; quantum statistics: Bose-Einstein and Fermi-Dirac distributions; density of states; black-body radiation; Bose-Einstein condensation; Fermi energy; quantum gases and the classical limit; Maxwell-Boltzmann distribution; equipartition of energy; negative temperatures.

Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics, Chemistry and Physics, Physics and Mathematics, Theoretical Physics and Mathematics	
Pre-requisite(s):	PH2011, PH2012, [MT2001 or (MT2501 and MT2503)], (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])	
Required for:	PH4025, PH5014	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.	
	Scheduled learning: 35 hours	**Guided independent study:** 115 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinations = 0%, Coursework = 20%	
	As used by St Andrews: 2-hour Written Examination = 80%, Coursework = 20%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Prof S Lee	
Lecturer(s)/Tutor(s):	Prof S Lee, Dr I Leonhardt	

PH3014 Transferable Skills for Physicists

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	Whole Year
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Not automatically available to General Degree students.			
Planned timetable:	10.00 am Wed, occasional 10.00 am Fri			
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, thus extending student knowledge and understanding of their chosen subject. Guidance, practice and assessment will be provided in the preparation and delivery of talks, critical reading of the literature, scientific writing, developing and writing a case for resources to be expended to investigate a particular area of science, tackling case studies.				
Programme module type:	Compulsory for Astrophysics, Physics, Theoretical Physics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), Entry to the School's Honours programme.		**Anti-requisite(s):**	PH4040
Learning and teaching methods and delivery:	**Weekly contact**: Through the year there are 8 lectures, 7 tutorials, 2 workshops, and about 14 hours of presenting and/or critically evaluating talks.			
	Scheduled learning: 29 hours		**Guided independent study:** 121 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%			
	As used by St Andrews: Coursework on basis of exercises = 100%			
Re-Assessment pattern:	No Re-Assessment available - Assignment based			
Module Co-ordinator:	Dr B D Sinclair			
Lecturer(s)/Tutor(s):	Dr B D Sinclair and others			

PH3061 Quantum Mechanics 1

SCOTCAT Credits:	10	SCQF Level 9	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	9.00 am Tue, Thu and Mon 4 pm			
This module introduces the main features of quantum mechanics. The syllabus includes: early ideas on quantisation, the emergence of the Schrödinger equation, the interpretation of the wave function and Heisenberg's uncertainty relation. The concepts of eigenfunctions and eigenvalues. Simple one-dimensional problems including potential wells and barriers; the linear harmonic oscillator. Solution of the Schrödinger equation for central forces, the radial Schrödinger equation, and the hydrogen atom.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics, Chemistry and Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503)			
Co-requisite(s):	PH3081 or PH3082 unless already have [MT2003 or (MT2506 and MT2507)]		**Required for:**	PH3062, PH4022, PH4025, PH4028, PH4037, PH4040, PH5002, PH5003, PH5004, PH5005, PH5012, PH5014, PH5015,
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and fortnightly tutorials.			
	Scheduled learning: 26 hours		**Guided independent study:** 74 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinations = 0%, Coursework = 20%			
	As used by St Andrews: 2-hour Written Examination = 80%, Coursework = 20%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr A Kohnle			
Lecturer(s)/Tutor(s):	Dr A Kohnle			

PH3062 Quantum Mechanics 2

SCOTCAT Credits:	10	SCQF Level 9	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	9.00 am Wed, Fri			
This module explores more of the key concepts of quantum mechanics, assuming a knowledge of the material in PH3061. The syllabus includes time-independent and time-dependent perturbation theory, including the treatment of degenerate states. The course includes a matrix description of spin, the Bloch sphere representation of spin, systems of interacting spins, and the quantum mechanics of a system of identical particles, which leads to the distinction between fermions and bosons.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics, Chemistry and Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH3061, (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])			
Required for:	PH4021, PH4022, PH4028, PH4037, PH4040, PH5002, PH5003, PH5004, PH5005, PH5012, PH5014, PH5015			
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and fortnightly tutorials.			
	Scheduled learning: 26 hours		**Guided independent study:** 74 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinations = 0%, Coursework = 20%			
	As used by St Andrews: 2-hour Written Examination = 80%, Coursework = 20%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr A Kohnle			
Lecturer(s)/Tutor(s):	Dr A Kohnle			

PH3074 Electronics

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	9.00 am Mon, Wed, Fri, 10.00 am Fri lab			
This module gives a basic grounding in practical electronics. It introduces and develops the basic principles underlying the synthesis and analysis of digital and analogue circuits. The module is divided into three parts: an introductory section which reviews those parts of electromagnetism most related to electronics, including d.c. and a.c. circuit theory; a section on transistors and amplifiers including simple transistor circuits and noise considerations; and a section on digital electronics including logic gates, flip-flops and the design of circuits with applications to counters, latches registers etc.				
Programme module type:	Compulsory for Physics MPhys Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503)			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures, tutorials or short lab sessions			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 75%, Practical Examinations = 0%, Coursework = 25%			
	As used by St Andrews: 2-hour Written Examination = 75%, Coursework = 25%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr P Cruickshank			
Lecturer(s)/Tutor(s):	Dr P Cruickshank			

PH3080 Computational Physics

SCOTCAT Credits:	10	SCQF Level 9	**Semester:**	Whole Year (semester 1 plus start of semeser 2)
Academic year:	2015/6 & 2016/7			
Planned timetable:	3.00 pm Mon and 3.5 hours on 1 afternoon of Tue, Thu, Fri			
This module is designed to develop a level of competence in Mathematica, a modern programming language currently used in many physics research labs for mathematical modelling. No prior experience is required. The module starts with a grounding in the use of Mathematica and discusses symbolic solutions and numerical methods. The main focus will be the use of Mathematica for problem solving in physics. The module is continually assessed through short tests and assignments, with the bulk of the assessment based on the submission of a Mathematica project.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics This or one of the computational maths modules is compulsory for the joint degrees with Mathematics.			
Pre-requisite(s):	PH2001, PH2012, MT2001 or (MT2501 and MT2503)		**Anti-requisite(s):**	PH3082
Required for:	This or PH3082 or similar is recommended for all physics and astronomy level 4 and 5 modules			
Learning and teaching methods and delivery:	**Weekly contact**: 1-hour lecture weeks 1-11, 3.5-hours PC classroom session in each of weeks 1-5 and 7-8, 3-hour project contact time weeks 9-11.			
	Scheduled learning: 44 hours		**Guided independent study:** 56 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%			
	As used by St Andrews: Coursework = 100%			
Re-Assessment pattern:	No Re-Assessment available - laboratory based			
Module Co-ordinator:	Dr M Mazilu			
Lecturer(s)/Tutor(s):	Dr M Mazilu, Dr A Gillies, Dr G Smith			

PH3081 Mathematics for Physicists

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	10.00 am even Mon, Tue, Thu, 2.00 pm odd Mon			

The module aims to develop mathematical techniques that are required by a professional physicist or astronomer. There is particular emphasis on the special functions which arise as solutions of differential equations which occur frequently in physics, and on vector calculus. Analytic mathematical skills are complemented by the development of computer-based solutions. The emphasis throughout is on obtaining solutions to problems in physics and its applications. Specific topics to be covered will be Fourier transforms, the Dirac delta function, partial differential equations and their solution by separation of variables technique, series solution of second order ODEs, Hermite polynomials, Legendre polynomials and spherical harmonics. The vector calculus section covers the basic definitions of the grad, div, curl and Laplacian operators, their application to physics, and the form which they take in particular coordinate systems.

Programme module type:	Compulsory for Astrophysics, Single and Joint Physics, Theoretical Physics PH3081 is compulsory for Physics and Mathematics, Theoretical Physics and Mathematics if MT2003 is not taken in Second Year	
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503)	
Anti-requisite(s):	PH3082, May be taken with MT2506 OR MT3504, but not with both	
Required for:	All PH and AS level 4 and 5 modules, and second semester level 3 modules, unless other pre-requisite(s) (eg PH3082) taken.	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures plus tutorials.	
	Scheduled learning: 35 hours	**Guided independent study:** 115 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%	
	As used by St Andrews: 2-hour Written Examination = 80%, Coursework (Class Tests) = 20%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr C Baily	
Lecturer(s)/Tutor(s):	Dr C Baily	

PH3082 Mathematics for Chemistry / Physics

SCOTCAT Credits:	20	SCQF Level 9	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Available only to Chemistry and Physics MSci students			
Planned timetable:	10.00 am even Mon, Tue, Thu, 2.00 pm odd Mon, 3.00 pm Mon, and one afternoon 2.00-5.30 pm of Tue, Thu, Fri			

This module consists of the content and assessment of all of PH3081 and the first part of PH3080. The module aims to develop mathematical techniques that are required by a professional physicist or astronomer. There is particular emphasis on the special functions which arise as solutions of differential equations which occur frequently in physics, and on vector calculus. Analytic mathematical skills are complemented by the development of computer-based solutions. The emphasis throughout is on obtaining solutions to problems in physics and its applications. Specific topics to be covered will be Fourier transforms, the Dirac delta function, partial differential equations and their solution by separation of variables technique, series solution of second order ODEs, Hermite polynomials, Legendre polynomials and spherical harmonics. The vector calculus section covers the basic definitions of the grad, div, curl and Laplacian operators, their application to physics, and the form which they take in particular coordinate systems. In the other section of the module students are introduced to the Mathematica package, and shown how this can be used to set up mathematical models of physical systems.

Programme module type:	Compulsory for Chemistry and Physics MSci	
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), entry to MSci Chemistry and Physics degree programme	
Anti-requisite(s):	PH3080, PH3081, May be taken with MT2506 OR MT3504, but not with both	
Required for:	All PH and AS level 4 and 5 modules, and second semester level 3 modules, unless other related taken (eg PH3080 and PH3081) taken.	
Learning and teaching methods and delivery:	**Weekly contact**: Overlap with PH3081 is 3 lectures a week plus 0.5 tutorials a week. Overlap with PH3082 is in total 4 hours lectures, 18 hours supported computing lab sessions, and 3 hours test	
	Scheduled learning: 63 hours	**Guided independent study:** 137 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 75%, Practical Examinations = 0%, Coursework = 25%	
	As used by St Andrews: 2-hour Written Examination = 60%, Coursework = 40%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr C Baily	
Lecturer(s)/Tutor(s):	Dr C Baily, Dr M Mazilu, Dr A Gillies, Dr G Smith	

PH3101 Physics Laboratory 1

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	2.00 pm - 5.30 pm Mon and 2.00 pm - 5.30 pm Thu			
The aims of the module are (i) to familiarise students with a wide variety of experimental techniques and equipment, and (ii) to instill an appreciation of the significance of experiments and their results. The module consists of sub-modules on subjects such as solid state physics, lasers, interfacing, and signal processing and related topics.				
Programme module type:	Compulsory for Physics BSc and MPhys, Chemistry and Physics MSci Optional for Astrophysics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503)			
Required for:	PH4111 (unless PH4105 is taken), PH5101			
Learning and teaching methods and delivery:	**Weekly contact**: 2 x 3.5-hour laboratories.			
	Scheduled learning: 72 hours		**Guided independent study:** 78 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%			
	As used by St Andrews: Coursework = 100%			
Re-Assessment pattern:	No Re-Assessment available - laboratory based			
Module Co-ordinator:	Dr C Rae			
Lecturer(s)/Tutor(s):	Dr C Rae and others			

PH4022 Nuclear and Particle Physics

SCOTCAT Credits:	10	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	12.00 noon Wed and Fri			
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 beta-decay, alpha-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.				
Programme module type:	Compulsory for Astrophysics, Physics, Theoretical Physics, Chemistry and Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3061 and PH3062		**Anti-requisite(s):**	PH4040
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures or tutorials.			
	Scheduled learning: 22 hours		**Guided independent study:** 78 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 90%, Practical Examinations = 0%, Coursework = 10%			
	As used by St Andrews: 2-hour Written Examination = 90%,Coursework = 10%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr A Kohnle			
Lecturer(s)/Tutor(s):	Dr A Kohnle			

PH4025 Physics of Electronic Devices

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	9.00 am even Mon, Tue, Thu, 3.00 pm odd Mon			
The module 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 module should acquire a sufficient background to understand a wide variety of modern semiconductor devices. The module 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.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]),PH3007, PH3012, PH3061			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 2-hour Written Examination = 100%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr L O'Faolain			
Lecturer(s)/Tutor(s):	Dr L O'Faolain, Prof J Scott			

PH4026 Signals and Information

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	11.00 am odd Mon, Wed, Fri, 2.00 pm even Mon			
This module gives an introduction to what are signals and information, and how they are measured and processed. It also covers the importance of coherent techniques such as frequency modulation and demodulation and phase sensitive detection. The first part of the module concentrates on information theory and the basics of measurement, with examples. Coherent signal processing is then discussed, including modulation/demodulation, frequency mixing and digital modulation. Data compression and reduction ideas are illustrated with real examples and multiplexing techniques are introduced. The module concludes with a discussion of basic antenna principles, link gain, and applications to radar.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics (Single and Joint)			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 2-hour Written Examination = 100%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr P Cruickshank			
Lecturer(s)/Tutor(s):	Dr P Cruickshank			

PH4027 Optoelectronics and Nonlinear Optics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	9.00 am Tue, Thu, 3.00 pm Fri			
The module 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; 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.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics Undergraduate Programmes.			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3007 (Undergraduates)			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 2-hour Written Examination = 100%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Prof I D W Samuel			
Lecturer(s)/Tutor(s):	Prof I D W Samuel, Dr M Mazilu			

PH4028 Advanced Quantum Mechanics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	12.00 noon even Mon, Tue, Thu, 2.00 pm Fri			
This module builds on the material of PH3061 and PH3062 Quantum Mechanics 1 and 2 to present some of the important current and advanced topics in quantum mechanics. The mathematics of complex analysis is introduced to allow this to be used for relevant quantum mechanics problems. Scattering theory is developed using partial waves and Green's functions, leading to a discussion of quantum degenerate gases. Advanced topics in perturbation theory including WKB approximation for exploring differential equations. The density matrix formalism as the general state description in open quantum systems is presented; open system dynamics are described within the formalism of the density matrix master equation. Quantum information processing is covered, including concepts such as qubits, quantum entanglement, quantum teleportation, and measurement based quantum computing.				
Programme module type:	Compulsory for Theoretical Physics Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH3061, PH3062, PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])			
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and some tutorials.			
	Scheduled learning: 30 hours		**Guided independent study:** 120 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 2-hour Written Examination = 100%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr B Lovett			
Lecturer(s)/Tutor(s):	Dr B Lovett			

PH4031 Fluids

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	11.00 am even Mon, Tue, Thu, 2.00 pm odd Mon			
This module provides an introduction to fluid dynamics, and addresses the underlying physics behind many everyday flows that we see around us. It starts from a derivation of the equations of hydrodynamics and introduces the concept of vorticity and the essentials of vorticity dynamics. The influence of viscosity and the formation of boundary layers is described with some straightforward examples. The effect of the compressibility of a fluid is introduced and applied to shock formation and to the conservation relations that describe flows through shocks. A simple treatment of waves and instabilities then allows a comparison between theory and readily-observed structures in clouds, rivers and shorelines.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics Two of PH4031, AS4011, AS4012, AS4025, AS4015 compulsory for Astrophysics BSc Two of PH4031, AS4025, AS4015 compulsory for Astrophysics MPhys			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])			
Required for:	AS5002 (strongly recommended, though not required)			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures and some tutorials.			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 2-hour Written Examination = 100%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Prof M Jardine			
Lecturer(s)/Tutor(s):	Prof M Jardine			

PH4032 Special Relativity and Fields

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	3.00 pm Tue, 4.00 pm Tue, Fri			
The module analyses classical fields in physics such as the electromagnetic field. Fields are natural ingredients of relativity, because they serve to communicate forces with a finite velocity (the speed of light). The module covers the tensor formalism of special relativity, relativistic dynamics, the Lorentz force, Maxwell's equations, retarded potentials, symmetries and conservation laws, and concludes with an outlook to general relativity.				
Programme module type:	Compulsory for Theoretical Physics, Theoretical Physics and Mathematics Optional for Astrophysics, Physics, Physics and Mathematics			
Pre-requisite(s):	PH3007, PH3081 (or MT equivalent), PH4038		**Required for:**	PH5011 (recommended, though not required)
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 75%, Practical Examinations = 0%, Coursework = 25%			
	As used by St Andrews: 2-hour Written Examination = 75%, Coursework (assessed tutorial questions) = 25%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr N Korolkova			
Lecturer(s)/Tutor(s):	Dr N Korolkova			

PH4034 Laser Physics 1

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	9.00 am Mon, Wed, Fri			
This module presents a basic description of the main physical concepts upon which an understanding of laser materials, operations and applications can be based. The 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.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])			
Required for:	PH5016 (unless PH4035 is taken) - also recommended for PH5005			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 90%, Practical Examinations = 0%, Coursework = 10%			
	As used by St Andrews: 2-hour Written Examination = 90%, Coursework = 10%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr F Koenig			
Lecturer(s)/Tutor(s):	Dr F Koenig			

PH4035 Principles of Optics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Planned timetable:	12.00 noon odd Mon, Wed, Fri , 3.00 pm even Tue			
This module 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.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])			
Required for:	PH5016 (unless PH4034 is taken)			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 75%, Practical Examinations = 0%, Coursework = 25%			
	As used by St Andrews: 2-hour Written Examination = 75%, Coursework = 25%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr F Koenig			
Lecturer(s)/Tutor(s):	Dr F Koenig			

PH4036 Physics of Music

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	12.00 noon Mon, Tue, Thu			

Musical instruments function according to the laws of physics contained in the wave equation. Wind instruments, the human voice and the acoustics of concert halls can be explained largely by considering waves in the air, but understanding drums, percussion, string instruments and even the ear itself involves studying the coupling of waves in various media. The concepts of pitch, loudness and tone are all readily explained in quantitative terms as are the techniques that musicians and instrument makers use to control them. The analysis of musical instruments naturally culminates in a look at how musical sound may be synthesised.

Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics	
Pre-requisite(s):	PH2011, PH2012, [MT2001 or (MT2501 and MT2503)], Admission to an Honours programme in the School of Physics and Astronomy and prior or concurrent attendance at PH3081 or PH3082	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.	
	Scheduled learning: 32 hours	**Guided independent study:** 118 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%	
	As used by St Andrews: 2-hour Written Examination = 100%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr J Kemp	
Lecturer(s)/Tutor(s):	Dr J Kemp	

PH4037 Physics of Atoms

SCOTCAT Credits:	10	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	This module is expected to run every year from 2013/14, and is intended for students who started their honours programme in the School in 2012/13 and later.			
Planned timetable:	11.00 am Tue, Thu			
This module provides a rational basis to the identification of atomic energy states and the various interactions of electrons within atoms. The syllabus includes: electron cloud model of an atom; electron spin and magnetic moment; spin-orbit interactions; one, two and many-electron systems; selection rules and line intensities for electric-dipole transitions; Lande g-factors; weak Zeeman and strong Paschen-Back magnetic field effects; hyperfine structure and Lamb shifts.				
Programme module type:	Compulsory for Physics, Astrophysics, Theoretical Physics, Chemistry and Physics MSci Optional for Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, [MT2001 or (MT2501 and MT2503)], PH3061, PH3062		**Anti-requisite(s):**	PH4021
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures or tutorials.			
	Scheduled learning: 22 hours		**Guided independent study:** 78 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 2-hour Written Examination = 100%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr D Cassettari			
Lecturer(s)/Tutor(s):	Dr D Cassettari, Dr P Wahl, Dr G Bruce			

PH4038 Lagrangian and Hamiltonian Dynamics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2015/6 & 2016/7			
Availability restrictions:	This module is intended for students who started their honours programme in the School in 2012/13 and later.			
Planned timetable:	10.00 am odd Mon, Tue, Thu, 2.00 pm even Fri			
The module covers the foundations of classical mechanics as well as a number of applications in various areas. Starting from the principle of least action, the Lagrangian and Hamiltonian formulations of mechanics are introduced. The module explains the connection between symmetries and conservation laws and shows bridges between classical and quantum mechanics. Applications include the central force problem (orbits and scattering) and coupled oscillators.				
Programme module type:	Compulsory for Astrophysics MPhys, Physics MPhys, Theoretical Physics Optional for Astrophysics BSc, Chemistry and Physics MSci, Physics BSc, Physics and Mathematics One of PH4038 and MT4507 compulsory for Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]		**Anti-requisite(s):**	MT4507
Learning and teaching methods and delivery:	**Weekly contact**: 2 or 3 lectures and some tutorials			
	Scheduled learning: 26 hours		**Guided independent study:** 124 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 75%, Practical Examinations = 0%, Coursework = 25%			
	As used by St Andrews: 2-hour Written Examination = 75%, Coursework = 25%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr B Braunecker			
Lecturer(s)/Tutor(s):	Dr B Braunecker			

PH4039 Solid State Physics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	11.00 am Wed, Fri, 2.00 pm Fri			
This module is intended to show how the various 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 applied to typical solids such as simple metals, silicon and other semiconductors, and magnetic materials.				
Programme module type:	Compulsory for Physics, Theoretical Physics, Chemistry and Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]). PH3012 or CH3717, PH3061 or CH3712		**Anti-requisite(s):**	
Co-requisite(s):	PH3061 unless taken previously		**Required for:**	PH5014
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials			
	Scheduled learning: 34 hours		**Guided independent study:** 116 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinations = 0%, Coursework = 20%			
	As used by St Andrews: 2-hour Written Examination = 80%, Coursework = 20%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Prof S Lee			
Lecturer(s)/Tutor(s):	Prof S Lee			

PH4040 Nuclear and Particle Physics (Extended)

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Available only to students on the Physics and Logic and Philosophy of Science (to be Physics and Philosophy), and Physics and Computer Science programmes.			
Planned timetable:	12.00 noon Wed and Fri, 10.00 am Wed, occasional 10 am Fri			
The first 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 betadecay, alpha-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. The second aim of this module is to develop research skills, and oral and written communication skills in science. Participants will be given training in the use of bibliographic databases, use of the scientific literature, oral and written communication skills, and will develop these skills through structured assignments.				
Programme module type:	Compulsory for Physics and Logic and Philosophy of Science (to be Physics and Philosophy), and Physics and Computer Science			
Pre-requisite(s):	PH3061, PH3062, Entry to BSc Honours in either Logic and Philosophy of Science and Physics (to be Physics and Philosophy) or Computer Science and Physics		**Anti-requisite(s):**	PH4022, PH3014
Co-requisite(s):			**Required for:**	
Learning and teaching methods and delivery:	**Weekly contact**: 2 x lectures (x 11 weeks) plus 6 further lectures, 4 tutorials, 1 workshop and 2 hours of giving and evaluating tasks.			
	Scheduled learning: 35 hours		**Guided independent study:** 115 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 60%, Practical Examinations = 0%, Coursework = 40%			
	As used by St Andrews: 2-hour Written Examination = 60%, Coursework = 40%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr A Kohnle			
Lecturer(s)/Tutor(s):	Dr A Kohnle, Dr B D Sinclair, and others			

PH4105 Physics Laboratory 2

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	2.00 pm - 5.30 pm Mon and 2.00 pm - 5.30 pm Thu			
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 sub-modules on topics such as solid state physics, optics, interfacing, and signal processing.				
Programme module type:	Compulsory for Physics Optional for Astrophysics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)])			
Required for:	PH4111 (unless PH3101 is taken)			
Learning and teaching methods and delivery:	**Weekly contact**: 2 x 3.5-hour laboratories.			
	Scheduled learning: 70 hours		**Guided independent study:** 80 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%			
	As used by St Andrews: Coursework = 100%			
Re-Assessment pattern:	No Re-Assessment available - laboratory based			
Module Co-ordinator:	Dr C Rae			
Lecturer(s)/Tutor(s):	Dr C Rae and others			

PH4111 Physics Project (BSc)

SCOTCAT Credits:	30	SCQF Level 10	**Semester:**	Whole Year
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only in the final year of a Physics BSc programme			
Planned timetable:	Half time in second semester, plus some preparation in first semester.			

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 pre-project report on a topic which is usually related to the theme of the project. 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. Project choice and some preparatory work is undertaken in semester one, but normally most of the 30 credits' worth of work is undertaken in semester two.

The aim is that students provide the intellectual drive for the project work, and should take on a role similar to that of a research student in the School. Support will be offered by the academic staff member(s) supervising the project and usually also by other members of a research team. Many projects will be carried out in the School's research labs, but other arrangements are possible. A pre-project report precedes the experimental/computational/theoretical work of the project, and is expected to be directly relevant to the subsequent experimental studies.

Programme module type:	Compulsory for Single Honours Physics BSc, this or the other subject's project mdoule for Joint Honours BSc Physics and Logic and Philosophy of Science, Physics and Computer Science,		
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]). At least one of PH3101, PH4105	**Anti-requisite(s):**	AS4103, AS5101, PH5101, PH5103, PH4796
Learning and teaching methods and delivery:	**Weekly contact**: Project students work "half-time" on their project through semester 2. All students must meet weekly with their project supervisor and attend fortnightly meetings with their peer-support group. Most projects are based in research labs in the School, where members of research teams will provide supervision ranging from safety cover to assistance with equipment and discussion of interpretation of results – it is expected that the 20 hours a week will be primarily in this environment.		
	Scheduled learning: 140 hours	**Guided independent study:** 160 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%		
	As used by St Andrews: Coursework (Review essay, Report and Oral Examination) = 100%		
Re-Assessment pattern:	No Re-Assessment available - Final year project		
Module Co-ordinator:	Dr P King		
Lecturer(s)/Tutor(s):	School staff		

PH4796 Joint Project (30cr)

SCOTCAT Credits:	30	SCQF Level 10	**Semester:**	Either or Whole Year
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Available only to students in the final year of the Honours Programme on a joint honours BSc degree involving this School, and who have completed the Letter of Agreement. No student may do more than one project module.			
Planned timetable:	To be arranged.			

The aim of the project is to develop and foster the skills of experimental design, appropriate research management and analysis, covering both physics and one of computing, mathematics, and philosophy. The topic and area of research should be chosen in consultation with the supervisors in the two schools in order to determine that the student has access to resources as well as a clear plan of preparation.The project aims to develop students' skills in searching the literature in physics and their other discipline, the evaluation and interpretation of data, and in the presentation of results. The main project is preceded by a pre-project report on a topic which is related to the theme of the project. There is no specific syllabus for this module. Project choice and some preparatory work is undertaken in semester one, but normally most of the 30 credits' worth of work is undertaken in semester two.

The aim is that students provide the intellectual drive for the project work, and should take on a role similar to that of a research student in the School. Support will be offered by the academic staff members supervising the project and usually also by other members of a research team.

Programme module type:	Optional for students on Joint Honours BSc undergraduate degrees in the School of Physics & Astronomy
Pre-requisite(s):	A Letter of Agreement
Anti-requisite(s):	AS4103, AS5101, PH4111, PH5101, PH5103 or More than 30 credits in other dissertation / project modules
Learning and teaching methods and delivery:	**Weekly contact**: As per Letter of Agreement.
Assessment pattern:	As per Letter of Agreement.
Re-Assessment pattern:	As per Letter of Agreement.
Module Co-ordinator:	As per Letter of Agreement.

PH5002 Foundations of Quantum Mechanics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	2.00 pm Mon, Tue, Fri			
This module consists of seven parts: (i) classical and quantum systems; (ii) vector spaces, Hilbert spaces, operators and probability; (iii) basic postulates of quantum mechanics for observables with discrete spectra; (iv) illustrative examples; (v) treatment of continuous observables in terms of probability distribution functions and the spectral functions; (vi) quantum theory of orbital and spin angular momenta, Pauli-Schrodinger equation and its applications; (vii) introduction to relativistic quantum mechanics.				
Programme module type:	Optional for Astrophysics MPhys, Physics MPhys, Chemistry and Physics, Theoretical Physics, Theoretical Physics and Mathematics			
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]) PH3061 and PH3062. PG - Relevant Quantum Mechanics			
Required for:	Recommended, but not required, for PH5004			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 30 hours		**Guided independent study:** 120 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 2-hour Written Examination = 100%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr K Wan			
Lecturer(s)/Tutor(s):	Dr K Wan			

PH5003 Group Theory

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	12.00 noon Wed, Fri, 3.00 pm Mon			

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 connectedness, 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.

Programme module type:	Optional for Astrophysics MPhys, Physics MPhys, Chemistry and Physics, Theoretical Physics and Mathematics	
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3061 and PH3062. PG - Relevant undergraduate mathematics and physics.	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.	
	Scheduled learning: 32 hours	**Guided independent study:** 118 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%	
	As used by St Andrews: 2-hour Written Examination = 100%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Prof J Cornwell	
Lecturer(s)/Tutor(s):	Prof J Cornwell	

PH5004 Quantum Field Theory

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	2.00 pm Thu, 3.00 pm Tue, Fri			

This module presents an introductory account of the ideas of quantum field theory and of simple applications thereof, including quantization of classical field theories, second quantization of bosons and fermions, the failure of single particle interpretation of relativistic quantum mechanics, solving simple models using second quantization, Feynman's path integral approach to quantum mechanics and its relation to classical action principles, field integrals for bosons and fermions, the relationship between path integral methods and second quantization.

Programme module type:	Compulsory for Theoretical Physics Optional for Astrophysics MPhys, Physics MPhys, Chemistry and Physics, Theoretical Physics and Mathematics	
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]),PH3012, PH3061, PH3062 and PH4038 or MT4507.PG - Relevant undergraduate mathematics and physics	
Co-requisite(s):	At least one of PH5002 and PH5012 is recommended but not compulsory.	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.	
	Scheduled learning: 30 hours	**Guided independent study:** 120 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 90%, Practical Examinations = 0%, Coursework = 10%	
	As used by St Andrews: 2-hour Written Examination = 90%, Coursework = 10%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr J Keeling	
Lecturer(s)/Tutor(s):	Dr J Keeling	

PH5005 Laser Physics 2

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	10.00 am Mon, Tue, Wed, Thu			

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.

Programme module type:	Optional for Astrophysics MPhys, Physics MPhys, Theoretical Physics, Chemistry and Physics, Theoretical Physics and Mathematics	
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3007, PH3061 and PH3062. PH4034 is recommended.	
Anti-requisite(s):	PH5180	
Learning and teaching methods and delivery:	**Weekly contact**: 4 lectures or tutorials.	
	Scheduled learning: 44 hours	**Guided independent study:** 106 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%	
	As used by St Andrews: 2.5-hour (open notes) Examination = 100%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr B Sinclair	
Lecturer(s)/Tutor(s):	Prof M Dunn, Dr L O'Faolain, Dr B Sinclair, Dr T Brown	

PH5011 General Relativity

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	9.00 am Wed, Fri, 3.00 pm Thu			

This module covers: 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.

Programme module type:	Optional for Astrophysics MPhys, Physics MPhys, Theoretical Physics, Chemistry and Physics, Theoretical Physics and Mathematics	
Pre-requisite(s):	UG - PH3081 or PH3082, PH3081 or PH3082 or [MT2003 or MT2506 and MT2507)], Recommended PH4038 and PH4032. PG - Relevant mathematics and physics	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.	
	Scheduled learning: 32 hours	**Guided independent study:** 118 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%	
	As used by St Andrews: 2-hour Written Examination = 100%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr H Zhao	
Lecturer(s)/Tutor(s):	Dr H Zhao, Dr M Dominik	

PH5012 Quantum Optics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	11.00 am Mon,Tue Thu			

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.

Programme module type:	Optional for Astrophysics MPhys, Physics MPhys, Theoretical Physics, Chemistry and Physics, Theoretical Physics and Mathematics	
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3061, PH3062, PH4028. PG - Relevant quantum mechanics and mathematics	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.	
	Scheduled learning: 32 hours	**Guided independent study:** 118 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%	
	As used by St Andrews: 2-hour Written Examination = 100%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr N Korolkova	
Lecturer(s)/Tutor(s):	Dr F Koenig, Dr N Korolkova	

PH5014 The Interacting Electron Problem in Solids

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	4.00 pm Mon, Tue, Thu			

The aim of this module is to give an overview of developments in modern condensed matter physics. The difficulties of a full quantum mechanical treatment of electrons with strong interactions will be discussed. Common existing approaches such as the Hubbard and t-J models and Fermi liquid theory will be compared. It will be shown that, although microscopic models can explain aspects of magnetism, they have little chance of capturing many other features of the fascinating low-energy physics of these systems. Instead, we introduce the principle of emergence, and show how it suggests radically new approaches to the problem of complexity in condensed matter physics and beyond. In this module, formal lectures will be combined with reading assignments, and the assessment will be based on marked homework together with an oral presentation followed by questions.

Programme module type:	Optional for Astrophysics MPhys, Physics MPhys, Theoretical Physics, Chemistry and Physics, Theoretical Physics and Mathematics	
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH4039, PH3012, PH3061, PH3062. PG - Relevant solid state physics, quantum mechanics and mathematics	
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and some tutorials.	
	Scheduled learning: 20 hours	**Guided independent study:** 130 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 50%, Coursework = 50%	
	As used by St Andrews: Coursework = 50%, Presentation plus Oral Examination = 50%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr P Wahl	
Lecturer(s)/Tutor(s):	Dr P Wahl, Prof A Mackenzie	

PH5015 Applications of Quantum Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	12.00 noon Mon, Tue, Thu			

Quantum physics is one of the most powerful theories in physics yet is at odds with our understanding of reality. In this module we show how laboratories around the world can prepare single atomic particles, ensembles of atoms, light and solid state systems in appropriate quantum states and observe their behaviour. The module includes studies of laser cooling, Bose-Einstein condensation, quantum dots and quantum computing. An emphasis throughout will be on how such quantum systems may actually turn into practical devices in the future. The module will include assessment based on tutorial work and a short presentation on a research topic.

Programme module type:	Optional for Astrophysics MPhys, Physics MPhys, Theoretical Physics, Chemistry and Physics, Theoretical Physics and Mathematics	
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3061, PH3062. PG - Relevant physics and mathematics	
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures (x 11 weeks) and a further 2 x 1-hour tutorials, 1 x 3-hour research lab visit, 3 hours student presentations during the semester.	
	Scheduled learning: 30 hours	**Guided independent study:** 120 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinations = 0%, Coursework = 20%	
	As used by St Andrews: 2-hour Written Examination = 80%, Coursework = 20%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr D Cassettari	
Lecturer(s)/Tutor(s):	Dr D Cassettari, Dr M Mazilu	

PH5016 Biophotonics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	9.00 am Mon, Wed, Fri			
The module will expose students to the exciting opportunities offered by applying photonics methods and technology to biomedical sensing and detection. A rudimentary biological background will be provided where needed. Topics include fluorescence microscopy and assays including time-resolved applications, optical tweezers for cell sorting and DNA manipulation, photodynamic therapy, lab-on-a-chip concepts and bio-MEMS. Two thirds of the module will be taught as lectures, including guest lectures by specialists, with the remaining third consisting of problem-solving exercises, such as writing a specific news piece on a research paper, assessed tutorial sheets and a presentation. A visit to a biomedical research laboratory using various photonics methods will also be arranged.				
Programme module type:	Optional for Astrophysics MPhys, Physics MPhys, Theoretical Physics, Chemistry and Physics, Theoretical Physics and Mathematics			
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH4034 or PH4035. PG - Relevant physics and mathematics			
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and some tutorials.			
	Scheduled learning: 24 hours		**Guided independent study:** 126 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinations = 0%, Coursework = 20%			
	As used by St Andrews: 2-hour Written Examination = 80%, Coursework = 20%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	Dr T Brown			
Lecturer(s)/Tutor(s):	Dr T Brown, Prof M C Gather, Dr C Penedo-Esteiro			

PH5023 Monte Carlo Radiation Transport Techniques

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Planned timetable:	2.00 pm Mon, Tue, Fri			
This module introduces the theory and practice behind Monte Carlo radiation transport codes for use in physics, astrophysics, atmospheric physics, and medical physics. Included in the module: recap of basic radiation transfer; techniques for sampling from probability distribution functions; a simple isotropic scattering code; computing the radiation field, pressure, temperature, and ionisation structure; programming skills required to write Monte Carlo codes; code speed-up techniques and parallel computing; three-dimensional codes. The module assessment will be 100% continuous assessment comprising homework questions and small projects where students will write their own and modify existing Monte Carlo codes.				
Programme module type:	Optional for Astronomy and Physics			
Pre-requisite(s):	PH2012, plus at least one of: AS3013, PH3080. PH3081, PH3082.			
Learning and teaching methods and delivery:	**Weekly contact**: 3 hours of lectures (x 6 weeks), 1-hour tutorials (x 5 weeks), during semester 3 x 3 hour supervised computer lab sessions			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%			
	As used by St Andrews: Coursework = 100%			
Re-Assessment pattern:	No Re-Assessment available - laboratory based			
Module Co-ordinator:	Dr K Wood			
Lecturer(s)/Tutor(s):	Dr K Wood			

PH5024 Surfaces, Symmetry, and Topology in Condensed Matter Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Available only to those in the final year of an MPhys programme			
Planned timetable:	10.00 am Tue, Wed, Thu			

This module focuses on current topics in modern solid state physics, concentrating on the rich structural and electronic phases that can be stabilized at surfaces of materials. The first part will provide an overview of the distinct environment which surfaces provide, as well as detailing the experimental probes that can be used to investigate them. The second part of the module will introduce the concepts of topology in the context of electronic states in condensed matter systems. It will concentrate on topologically non-trivial states of matter, phases that are not characterised by spontaneous symmetry breaking but rather by a distinct topology of the underlying bulk electronic system, but with a particular focus on the implications for stabilizing exotic states at surfaces, and experimental probes of these. The module will employ continuous assessment for both formative and summative assessment, with an emphasis on developing skills in critical reading of scientific literature, presenting relevant works in class discussions and performing simple numerical calculations. Tutorial sessions will be used to provide constructive feedback on problem sheets throughout the course period. Full-class discussions in a "journal-club" style will aid in developing understanding of critical reading of research papers and complex topics, while written feedback on presentations will provide assessment of individual and group presentations delivered by students during the module.

Programme module type:	Optional for MPhys programmes	
Pre-requisite(s):	PH3061, PH3062, (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3080, PH4037, PH4039	
Learning and teaching methods and delivery:	**Weekly contact**: 3 hours of lectures (x 7 weeks), 1-hour tutorials (x 4 weeks), 3-hour presentations (x 3 weeks)	
	Scheduled learning: 34 hours	**Guided independent study:** 116 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 40%, Coursework = 60%	
	As used by St Andrews: Coursework = 100%	
Re-Assessment pattern:	No Re-Assessment available - assignment based	
Module Co-ordinator:	Dr P King	
Lecturer(s)/Tutor(s):	Dr P Wahl, Dr P King	

PH5101 Physics Project (MPhys)

SCOTCAT Credits:	60	SCQF Level 11	**Semester:**	Whole Year
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally Available only to those in the final year of an MPhys Physics or MSci Chemistry and Physics degree programme			
Planned timetable:	Full time in second semester, following some work in first.			

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 pre-project report on a topic which is normally related to the theme of the project. There is no specific syllabus for this module. Students taking the MPhys degree select a project from a list offered, and are supervised by a member of staff. Project choice and some preparatory work is undertaken in semester one, but normally most of the 60 credits' worth of work is undertaken in semester two.

The aim is that students provide the intellectual drive for the project work, and should take on a role similar to that of a research student in the School. Support will be offered by the academic staff member(s) supervising the project and usually also by other members of a research team. Many projects will be carried out in the School's research labs, but other arrangements are possible. A pre-project report precedes the experimental/computational/theoretical work of the project, and is expected to be directly relevant to the subsequent experimental studies.

Programme module type:	Compulsory for Physics MPhys Either PH5101 or CH5441 is compulsory for Chemistry and Physics	
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3101 or PH4105	
Anti-requisite(s):	AS4103, AS5101, PH4111, PH5103, PH4796	
Learning and teaching methods and delivery:	**Weekly contact**: Project students work "full-time" on their MPhys project through semester 2. All students must meet weekly with their project supervisor and attend fortnightly meetings with their peer-support group. Most projects are based in research labs in the School, where members of research teams will provide supervision ranging from safety cover to assistance with equipment and discussion of interpretation of results – it is expected that the 40 hours a week will be primarily in this environment.	
	Scheduled learning: 300 hours	**Guided independent study:** 300 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%	
	As used by St Andrews: Coursework (Review essay, Report, and Oral Examination) = 100%	
Re-Assessment pattern:	No Re-Assessment available - Final year project	
Module Co-ordinator:	Dr P King	
Lecturer(s)/Tutor(s):	School staff	

PH5103 Project in Theoretical Physics (60)

SCOTCAT Credits:	60	SCQF Level 11	**Semester:**	Whole Year
Academic year:	2015/6 & 2016/7			
Availability restrictions:	Normally available only to those in the final year of a Theoretical Physics or Mathematics and Theoretical Physics degree programme.			
Planned timetable:	Full time for second semester folliowng some work in first			

This project in theoretical physics research aims to develop students' skills in searching the physics literature, in the design and implementation of investigations in theoretical/computational physics, in the evaluation and interpretation of data, and in the presentation of results.

The main project is preceded by a pre-project report on a topic which is normally related to the theme of the project. There is no specific syllabus for this module. Students taking the MPhys theoretical physics degree select a project from a list offered, and are supervised by a member of staff. Project choice and some preparatory work is undertaken in semester one, but normally most of the 60 credits' worth of work is undertaken in semester two. The aim is that students provide the intellectual drive for the project work, and should take on a role similar to that of a research student in the School. Support will be offered by the academic staff member(s) supervising the project. In addition to weekly meetings with the project supervisor, students will meet fortnightly with their peer support group. A pre-project report precedes the computational/theoretical work of the project, and is expected to be directly relevant to the subsequent studies.

Programme module type:	Compulsory for Theoretical Physics Either PH5103 or MT5999 is compulsory for Theoretical Physics and Mathematics	
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3062, PH3007, PH4022, PH4032. Some projects will need learning from specific modules - please contact potential supervisors.	
Anti-requisite(s):	PH5102, PH5101, PH4111, AS4103, AS5101, PH4796	
Learning and teaching methods and delivery:	**Weekly contact**: Project students should spend all their time in semester 2 working on the project. All students must meet weekly with their project supervisor, and attend fortnightly meetings with their peer-support group. Most of their time will be spent working on theoretical physics in an independent fashion, though with the opportunity to discuss things with their supervisor face to face or electronically. In addition, all theoretical physics project students are encouraged to attend the fortnightly meeting theoretical physics research seminars.	
	Scheduled learning: 28 hours	**Guided independent study:** 572 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%	
	As used by St Andrews: Coursework (review essay, report, oral examination) = 100%	
Re-Assessment pattern:	No Re-Assessment available - Final year project	
Module Co-ordinator:	Dr J Keeling	
Lecturer(s)/Tutor(s):	School staff	

PH5183 Photonics Applications

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2015/6			
Availability restrictions:	This module is intended for students in the final year of an MPhys or MSci programme involving the School, for those in the MSc in Photonics and Optoelectonic Devices MSc, and for those on the EngD degree in Photonics.			
Planned timetable:	9.00 am Mon, Wed, Fri, 11.00 am Wed, Fri, 12.00 noon Mon, Tue, Thu Depending on options taken			

Students on this module choose to do two of the following three sections:

Microphotonics and Plasmonics:This covers the Bragg effect, multilayer mirrors, defects causing confined cavity states, periodicity leading to bandstructure, scaling of bandstructure in reduced frequency, Bloch modes and photonic bandgap. It then considers photonic crystal waveguides, photonic crystal fibres, and supercontinuum generation in photonic crystal fibres. Plasmonics is based on oscillations of the free electronics in a metallic material. Resonances of Plasmons are the basis for a new class of materials called 'Metamaterials'. These are compared with photonic crystals. Applications include super-resolution imaging, optical cloaking, sensing, and surface enhanced Raman scattering.

Biophotonics:This will introduce students to the exciting opportunities offered by applying photonics methods and technology to biomedical sensing and detection. A rudimentary biological background will be provided where needed. Topics include fluorescence microscopy and assays including time-resolved applications, optical tweezers for cell sorting and DNA manipulation, photodynamic therapy, lab-on-a-chip concepts and bio-MEMS.

Optical Trapping and Atom Optics:Quantum physics is one of the most powerful theories in physics yet is at odds with our understanding of reality. In this course we show how laboratories around the world can prepare single atomic particles, ensembles of atoms, light and solid state systems in appropriate quantum states and observe their behaviour. The material includes optical cooling and trapping of atoms and ions, Fermi gases, studies of Bose-Einstein condensation, and matter-wave interferometry.

Students must not cover Biophotonics in both this module and PH5016/PH5264, and must not cover Optical Trapping and Atom Optics in both this module and PH5015/PH5267.

Programme module type:	Optional for Astrophysics MPhys, Physics and Mathematics BSc, Physics MPhys, Physics and Chemistry, Theoretical Physics MPhys	
Pre-requisite(s):	UG - PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]) PH3007. If Optical Trapping and Atom Optics option is chosen then PH3061, PH3062, and PH4037 are expected. PG - Relevant physics and mathematics.	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures and occasional tutorials.	
	Scheduled learning: 32 hours	**Guided independent study:** 118 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinations = 0%, Coursework = 20%	
	As used by St Andrews: 2-hour Written Examination = 80%, Coursework = 20%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr T Brown	
Lecturer(s)/Tutor(s):	Dr T Brown, Dr J C Penedo, Dr M Mazilu, Dr D Cassettari, Dr L O'Faolain, and Dr A Di Falco	