School of Physics & Astronomy

General degree students wishing to enter 3000-level modules and non-graduating students wishing to enter 3000-level or 4000-level modules must consult with the relevant Honours Adviser within the School to confirm they are properly qualified to enter the module.

Astronomy (AS) Modules

AS3013 Computational Astrophysics

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Academic year:	2016/7 & 2017/8			
Planned timetable:	2.00 pm - 5.30 pm Mon and Thu (TBC)			

The aim of this module is to introduce students to computational methods in astrophysics. Based on a general introduction to the programming language Fortran-90, students are shown how to apply simple numerical algorithms to calculate integrals, iteratively find the roots of non-linear equations, solve systems of ordinary differential equations, and to develop tools for statistical data analysis. Further emphasis is put on the development of skills to make convincing plots from the calculated data. The practical exercises include applications to the initial mass function in star formation, the calculation of orbits for N-body gravitational problems and in mean galactic potentials, and planet transition light-curves. Students gain experience with the basics of numerical accuracy, and the development of problem-solving algorithms in general."

Programme module type:	Compulsory for Astrophysics Optional for 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**: 2 x 3.5-hour supervised or taught sessions (x 11 weeks). Mostly hands-on guided work on computers, but with occasional presentation.	
	Scheduled learning: 77 hours	**Guided independent study:** 73 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%	
	As used by St Andrews: Coursework (practical work, the submission of computer code and computational solutions to given problems) = 100%	
Re-Assessment pattern:	No Re-Assessment available - laboratory based	
Module Co-ordinator:	Dr P Woitke	
Lecturer(s)/Tutor(s):	Dr P Woitke, Dr C Helling, **Prof K Horne**	

AS4010 Extragalactic Astronomy

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Planned timetable:	12.00 noon Mon, Tue, Thu (TBC)			

This module introduces the basic elements of extragalactic astronomy. This includes the morphological, structural and spectral properties of elliptical, spiral, quiescent and star-forming galaxies. We study how galaxy populations change from the distant galaxies in the early Universe into those observed in our local neighbourhood, including the coincident growth of super massive black holes at the centres of massive galaxies. Galaxy formation theory is introduced in relation to the growth of structure in a cold-dark matter, and galaxy evolution in regions of high and low density is investigated. The module includes a look at modern instrumentation used in extragalactic astrophysics.

Specialist lecturers from within the galaxy evolution research group will provide a direct link between material learnt in lectures and research currently being undertaken at the University of St Andrews.

Programme module type:	Compulsory for Astrophysics BSc and Mphys Optional for Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics		
Pre-requisite(s):	AS2001 or AS2101, PH2011, PH2012, MT2001 or (MT2501 and MT2503)	**Anti-requisite(s):**	AS4022 Cosmology and AS3011 Galaxies
Required for:	AS5003 unless other pre-requisites for that module met.		
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures occasionally replaced by tutorials		
	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 V Wild		
Lecturer(s)/Tutor(s):	Dr V Wild, **Prof K Horne**		

AS4011 The Physics of Nebulae and Stars 1

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Planned timetable:	**10.00 am Tue, Wed, Thu**			

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 emergent 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-ionise nebulae, interstellar shocks, nova and supernova shells, accretion discs, quasar-absorption-line clouds, radio synchrotron jets, radio pulsars, and x-ray plasmas. Monte-Carlo computational techniques are introduced to model radiative transfer.

Programme module type:	Compulsory for Astrophysics MPhys At least 2 of AS4011, AS4012, AS4015, AS4021, AS4025, PH4031 are compulsory for Astrophysics BSc Optional for Astrophysics, Physics BSc Optional for Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics MPhys		
Pre-requisite(s):	AS2001 or AS2101, PH2011, PH2012, MT2001 or (MT2501 and MT2503), PH3081 or PH3082 or MT2003 or (MT2506 and MT2507)		
Anti-requisite(s):	AS4023, AS3015	**Required for:**	AS4012
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures occasionally replaced by whole-group tutorials.		
	Scheduled learning: 30 hours	**Guided independent study:** 120 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 K Wood		
Lecturer(s)/Tutor(s):	Dr K Wood		

AS4012 The Physics of Nebulae and Stars 2

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2016/7 & 2017/8			
Planned timetable:	11.00 am odd Mon, Wed, Fri, 3.00 pm even Tue (TBC)			

This module develops the physics of stellar interiors and atmospheres from the basic equations of stellar structure introduced in AS2001/AS2101 using the radiative transfer concepts developed in Nebulae and Stars I. 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 spectrum. Computer-aided tutorial exercises illustrate the computational schemes that represent one of the triumphs of late twentieth-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.

Programme module type:	Compulsory for Astrophysics MPhys At least 2 of AS4011, AS4012, AS4015, AS4021, AS4025, PH4031 are compulsory for Astrophysics BSc Optional for Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics		
Pre-requisite(s):	AS4011	**Anti-requisite(s):**	AS4023, AS3015
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures occasionally replaced by whole-group tutorials.		
	Scheduled learning: 30 hours	**Guided independent study:** 120 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:	Prof A C Cameron		
Lecturer(s)/Tutor(s):	Prof A C Cameron and Dr P Woitke		

AS4015 Gravitational and Accretion Physics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2016/7 & 2017/8			
Planned timetable:	9.00 am - 10.00 am Mon, Wed, Fri			

This theoretical module is open to both physics and astrophysics students. It aims to explore the basics of gravitational dynamics and its application to systems ranging from planetary and stellar systems to clusters of galaxies. The dynamics responsible for the growth of super-massive black holes in galaxies and the accretion discs in stellar systems are also covered. Starting from two-body motion and orbits under a central-force law, the module describes the calculation of extended potentials and their associated orbits. The use of the virial theorem and the statistical treatment of large numbers of selfgravitating bodies is then developed with application to stellar systems. Applications of these methods are made to several different astrophysical objects ranging from collisions in globular clusters to the presence of dark matter in the universe.

Programme module type:	At least 2 of AS4015, AS4025, PH4031 are compulsory for Astrophysics MPhys At least 2 of AS4011, AS4012, AS4015, AS4021, AS4025, PH4031 are compulsory for Astrophysics BSc Optional for 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])	
Anti-requisite(s):	AS4021	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures occasionally replaced by whole-group 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:	Prof I Bonnell	
Lecturer(s)/Tutor(s):	Prof I Bonnell	

AS4025 Observational Astrophysics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Planned timetable:	2.00 pm - 5.30 pm Mon and Thu, plus some nights. (TBC)			

This is an observational and laboratory-based module that introduces students to the hands-on practical aspects of planning observing programmes, conducting the observations and reducing and analysing the data. Students use the James Gregory Telescope for CCD imaging and structural analysis of galaxies, and for CCD photometry of transiting exoplanet candidates. Further sources of data may be made available from international observatories. Observations are also secured at the University Observatory using a student-built radio telescope to observe low-frequency radio emission from the Galactic plane.

Students gain experience in observation, data analysis, the UNIX operating system, standard astronomical software packages and modelling, and report writing.

Programme module type:	At least 2 of AS4011, AS4012, AS4015, AS4021, AS4025, PH4031 are compulsory for Astrophysics BSc Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics	
Pre-requisite(s):	AS2001 or AS2101, PH2011, PH2012, (MT2001 or [MT2501 and MT2503])	
Learning and teaching methods and delivery:	**Weekly contact**: 2 x 3.5-hour laboratories plus supervised work in the observatory.	
	Scheduled learning: 78 hours	**Guided independent study:** 72 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 Cyganowski	
Lecturer(s)/Tutor(s):	Dr C Cyganowski, **Dr Sicilia-Aguilar, Prof A Cameron**	

AS4103 Astrophysics Project (BSc)

SCOTCAT Credits:	30	SCQF Level 10	**Semester:**	Whole Year
Academic year:	2016/7 & 2017/8			
Availability restrictions:	Available only to BSc Astrophysics students, and normally only in their final year.			
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 Astrophysics BSc	
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), AS3013, PH3081, PH3012 Entry to final year of BSc Astrophysics programme.	
Anti-requisite(s):	AS5101, PH4111, 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 computer clusters in the School, where students can benefit from peer support and informal interaction with academic supervisor and other members of research teams. 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 Article, Project Report, Presentation and Oral Examination) = 100%	
Re-Assessment pattern:	No Re-Assessment available - Final year project	
Module Co-ordinator:	Dr C Helling	
Lecturer(s)/Tutor(s):	Astronomy staff	

AS5001 Advanced Data Analysis

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Availability restrictions:	This module is intended for students in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	9.00 am Tue, Thu, 10.00 am Mon, 12.00 noon Thu and 3.00 pm - 5.00 pm Tue (Lab) (TBC)			
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.				
Programme module type:	At least two of AS5001, AS5002, and AS5003 are compulsory for MPhys Astrophysics Optional for Physics MPhys, Theoretical Physics, Theoretical Physics and Mathematics			
Pre-requisite(s):	Familiarity with scientific programming language essential, for example through AS3013 or PH3080. Entry to an MPhys programme in the School.			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials and some supervised computer lab sessions			
	Scheduled learning: 30 hours		**Guided independent study:** 120 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:	Prof K Horne			
Lecturer(s)/Tutor(s):	Prof K Horne			

AS5002 Magnetofluids and Space Plasmas

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Availability restrictions:	This module is intended for students in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	11.00 am Mon, Tue, Thu (TBC)			

This module is aimed at both physics and astrophysics students with interests in the physics of plasmas. The interaction of a magnetic field with an ionized gas (or plasma) is fundamental to many problems in astrophysics, solar- terrestrial physics and efforts to harness fusion power using tokamaks. 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.

Programme module type:	At least two of AS5001, AS5002, and AS5003 must be taken for MPhys Astrophysics Optional for Physics MPhys, Theoretical Physics, Theoretical Physics and Mathematics	
Pre-requisite(s):	Familiarity with scientific programming language essential, for example through AS3013 Computational Astrophysics or PH4030 or PH3080 Computational Physics. Entry to an MPhys programme.	
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 M M Jardine	
Lecturer(s)/Tutor(s):	Prof M M Jardine	

AS5003 Contemporary Astrophysics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Availability restrictions:	Available only to MPhys Astronomy students or a taught postgraduate programme in the School.			
Planned timetable:	**12.00 noon Wed, Fri and 5.00 pm Tue**			
This module will provide an annual survey of the latest, most interesting, developments in astronomy and astrophysics at the research level. Emphasis will be placed upon the application of knowledge and expertise gained by students in their other modules to these current research topics.				
Programme module type:	At least two of AS5001, AS5002, and AS5003 are compulsory for MPhys Astrophysics			
Pre-requisite(s):	AS4010, AS4012, PH3061, PH3081.			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures and 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 H Zhao			
Lecturer(s)/Tutor(s):	**Dr A Sicilia-Aguilar, Dr A Mortier, Dr H Zhao**			

AS5101 Astrophysics Project (MPhys)

SCOTCAT Credits:	60	SCQF Level 11	**Semester:**	Whole Year
Academic year:	2016/7 & 2017/8			
Availability restrictions:	Available only to final year MPhys Astronomy students			
Planned timetable:	Full time in second semester, plus some preparation in first semester.			

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 pre-project report. There is no specific syllabus for this module. Students taking the MPhys degree select a project from a list of those which are available, and are supervised by a member of the academic 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 sometimes also by other members of a research team. Many projects will be carried out in one of the astronomy computing clusters, 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 Astrophysics MPhys	
Pre-requisite(s):	PH2011, PH2012, (PH3081 or PH3082 or (MT2003 or (MT2506 and MT2507), AS3013, AS4012, Entry to final year MPhys Astronomy	
Anti-requisite(s):	AS4103, PH4111, PH5101, 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 astronomy computer clusters in the School, where students can benefit from peer support and informal interaction with academic supervisor and other members of research teams. 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 = 100%	
Re-Assessment pattern:	No Re-Assessment available - Final year project	
Module Co-ordinator:	Dr C Helling	
Lecturer(s)/Tutor(s):	Astronomy staff	

Physics (PH) modules

PH3007 Electromagnetism

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Academic year:	2016/7 & 2017/8			
Planned timetable:	9.05 am Mon even numbered weeks, 9.05 Tue, Thu, 15.05 Fri odd-numbered weeks (TBC)			
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 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:	2016/7 & 2017/8			
Planned timetable:	12.00 noon odd Mon, Wed, Fri, 2.00 pm even Tue (TBC)			

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:	2016/7 & 2017/8			
Availability restrictions:	Not automatically available to General Degree students.			
Planned timetable:	10.00 am Wed, occasional 10.00 am Fri (TBC)			
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:	2016/7 & 2017/8			
Planned timetable:	9.00 am Tue, Thu (TBC)			
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 the 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			
Required for:	PH3062, PH4022, PH4025, PH4028, PH4037, PH4040, PH5002, PH5003, PH5004, PH5005, PH5012, PH5014, PH5015,			
Co-requisite(s):	PH3081 or PH3082 unless already have [MT2003 or (MT2506 and MT2507)]	**Pre-requisite(s):**	PH2011, PH2012, MT2001 or (MT2501 and MT2503)	
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:	2016/7 & 2017/8			
Planned timetable:	9.00 am Wed, Fri (TBC)			
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:	2016/7 & 2017/8			
Planned timetable:	9.00 am Mon, Wed, Fri, 9.00 am or 11.00 am Fri lab			
This module provides a basic grounding in practical electronics. It introduces and develops the basic principles underlying the synthesis and analysis of analogue circuits. The module is divided into two parts: passive circuits, beginning with a review of dc circuit theory before moving onto complex impedance, passive ac circuits and diode applications; active circuits and amplifiers, including simple bipolar and FET amplifiers, operational and instrumentation amplifiers and applications.				
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: 33 hours		**Guided independent study:** 116 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:**	1
Academic year:	2016/7 & 2017/8			
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 is then on the ways in which Mathematica can be used for problem solving in physics and astrophysics.				
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):	PH2011, 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 lecture (x10 weeks), 3.5 hour supervised PC classroom time (x11 weeks)			
	Scheduled learning: 49 hours		**Guided independent study:** 51 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 30%, Practical Examinations = 0%, Coursework = 70%			
	As used by St Andrews: 3-hour Computer-based Examination = 30%, Coursework (Quizes) = 70%			
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			

PH3081 Mathematics for Physicists

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Planned timetable:	**10.00 am odd Mon, and even Tue, Thu, 2.00 pm even 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 = 20% (made up of Class Test = 15% and meaningful engagement with tutorial work = 5%)		
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:	2016/7 & 2017/8			
Availability restrictions:	Available only to Chemistry and Physics MSci students			
Planned timetable:	10.00 am odd Mon, Tue, Thu, 2.00 pm odd Mon, 3.00 pm Mon, and one afternoon 2.00-5.30 pm of Tue, Thu, Fri (TBC)			

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**: 4 x 1-hour lectures (x 11 weeks), 3.5-hour practicals (x 6 weeks), 1-hour tutorials (x 5 weeks)		
	Scheduled learning: 59 hours	**Guided independent study:** 141 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 C Baily		
Lecturer(s)/Tutor(s):	Dr C Baily		

PH3101 Physics Laboratory 1

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Academic year:	2016/7 & 2017/8			
Planned timetable:	2.00 pm - 5.30 pm Mon and 2.00 pm - 5.30 pm Thu (TBC)			
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:	2016/7			
Planned timetable:	12.00 noon Wed and Fri and 2.00 pm Tue			
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:	2016/7			
Planned timetable:	9.00 am even Mon, Tue, Thu, 3.00 pm odd Mon (TBC)			
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 A DI Falco			
Lecturer(s)/Tutor(s):	Dr A DI Falco			

PH4026 Signals and Information

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2016/7 & 2017/8			
Planned timetable:	11.00 am odd Mon, Wed, Fri, 2.00 pm even Mon (TBC)			
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 and Dr G Smith			

PH4027 Optoelectronics and Nonlinear Optics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Planned timetable:	9.00 am Tue, Thu, 3.00 pm Fri (TBC)			

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:	2016/7 & 2017/8			
Planned timetable:	12.00 noon Tue and Thu (TBC)			

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:	2016/7 & 2017/8			
Planned timetable:	11.00 am even Mon, Tue, Thu, 2.00 pm odd Mon (TBC)			

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:	Two of PH4031, AS4011, AS4012, AS4025, AS4015 compulsory for Astrophysics BSc Two of PH4031, AS4025, AS4015 compulsory for Astrophysics MPhys 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:	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:	2016/7 & 2017/8			
Planned timetable:	**3.00 pm Tue, 4.00 pm 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:	2016/7 & 2017/8			
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:	2016/7 & 2017/8			
Planned timetable:	.12.00 noon Mon, Wed, Fri (TBC)			
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:	2016/7 & 2017/8			
Planned timetable:	12.00 noon Mon, Tue, Thu (TBC)			

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	

PH4038 Lagrangian and Hamiltonian Dynamics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2016/7 & 2017/8			
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 (TBC)			

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 One of PH4038 and MT4507 compulsory for Theoretical Physics and Mathematics Optional for Astrophysics BSc, Chemistry and Physics MSci, Physics BSc, 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:	2016/7 & 2017/8			
Planned timetable:	11.00 am Wed, Fri, 2.00 pm Fri (TBC)			
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			
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:	Dr C Hooley			
Lecturer(s)/Tutor(s):	Dr C Hooley			

PH4040 Nuclear and Particle Physics with Advanced Skills

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2016/7 & 2017/8			
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. The module is expected to run every year from 2013/4.			
Planned timetable:	14.00 Tue, Noon Wed and Fri (all from week 4), 10.00 Wed, occasional 10.00 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 and Joint Honours degrees with Mathematics	
Pre-requisite(s):	PH3061, PH3062, Entry to BSc Honours in Philosophy and Physics or Computer Science and Physics or Mathematics and Physics or Theoretical Physics and Mathematics	
Anti-requisite(s):	PH4022, PH3014, PH4041	
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	

PH4041 Atomic, Nuclear, and Particle Physics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Planned timetable:	To be arranged.			

The aim of this module is to describe in terms of appropriate models, the structure and properties of the atom, including its nucleus, the classification of fundamental particles and the means by which they interact. The syllabus includes: electron cloud model of an atom, electron spin and magnetic moment, spin-orbit interactions, revision of single-electron atom and brief qualitative extension to multi-electron atoms, selection rules and line intensities for electric-dipole transitions; nuclear sizes, binding energy, properties of the strong nuclear force; radioactivity, the semi-empirical mass formula; nuclear stability, the shell model, magic numbers; 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.

Programme module type:	Compulsory for BSc and MPhys Astrophysics BSc and MPhys Physics MPhys Theoretical Physics MSci Chemistry and Physics	
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):	PH4022, PH4037, PH4040	
Learning and teaching methods and delivery:	**Weekly contact**: 2.7-hour lectures (x 10 weeks), 1-hour tutorials (x 3 weeks)	
	Scheduled learning: 30 hours	**Guided independent study:**120 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 00%, Practical Examinations = 0%, Coursework = 10%	
	As used by St Andrews: 2-hour Written Examination = 90%, Coursework (quizzes) = 10%	
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7	
Module Co-ordinator:	Dr A Kohnle	
Lecturer(s)/Tutor(s):	Dr A Kohnle, Dr D Cassettari	

PH4042 Concepts in Atomic Physics and Magnetic Resonance

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2016/7			
Planned timetable:	To be arranged.			
This module builds on the atomic physics covered in PH4041 to look at the atomic structure of helium and many-electron atoms, magnetic interactions within the atom (leading to fine and hyperfine splitting), the Zeeman effect, and topics in atom-light interaction. These well-established concepts are then used in contemporary topics such as cold atom physics and magnetic resonance, both of which are current research topics within the School.				
Programme module type:	Optional for all degrees in the School of Physics & Astronomy.			
Pre-requisite(s):	PH3061, PH3062, (PH4041 or special permission from the School)			
Anti-requisite(s):	PH4037			
Learning and teaching methods and delivery:	**Weekly contact**: 2.7-hour lectures (x 10 weeks)			
	Scheduled learning: 27 hours		**Guided independent study**:123 hours	
Assessment pattern:	**As defined by QAA:** 2-hour Written Examination = 80%, Coursework = 20%			
	As used by St Andrews: 2-hour Written Examination = 90%, Coursework (quizzes) = 10%			
Re-Assessment pattern:	Oral Re-Assessment, capped at grade 7			
Module Co-ordinator:	**Dr G Smith**			
Lecturer(s)/Tutor(s):	Dr D Cassettari, Dr G Smith, Dr J Lovett, **Dr P Wahl**			

PH4043 Studies in Physics and Chemistry

SCOTCAT Credits:	5	SCQF Level 10	**Semester:**	2
Academic year:	2016/7 & 2017/8			
Availability restrictions:	Available only to students in the honours years of the joint Chemistry and Physics degree programme.			
Planned timetable:	To be arranged.			
This module, which is for students on the joint degree programme Chemistry and Physics, provides guidance on literature research and communication skills. Students choose area(s) of interest relevant to the joint degree to explore and to write a review article and a provide a short presentation. The module thus addresses important professional skills, develops subject knowledge, and explicitly brings together the two halves of the degree programme.				
Programme module type:	Compulsory for the MSci in Chemistry and Physics			
Pre-requisite(s):	CH3441, PH3082, PH3061 This module is available only to students in the honours years of the joint			
Anti-requisite(s):	PH3014			
Learning and teaching methods and delivery:	**Weekly contact**: 1-hour lecture (x 4 weeks), 1-hour tutorial (x 5 weeks)			
	Scheduled learning: 9 hours		**Guided independent study: 41** hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 20%, Coursework = 80%			
	As used by St Andrews: Coursework (including Presentation (20%)= 100%			
Re-Assessment pattern:	No re-assessment available.			
Module Co-ordinator:	Dr B Sinclair			
Lecturer(s)/Tutor(s):	Dr B Sinclair			

PH4105 Physics Laboratory 2

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Planned timetable:	2.00 pm - 5.30 pm Mon and 2.00 pm - 5.30 pm Thu (TBC)			
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:	2016/7 & 2017/8			
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 module for Joint Honours BSc Physics and Logic and Philosophy of Science, Physics and Computer Science, BSc Physics and Mathematics	
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	

PH4112 Physics Project (Non-graduating - 120)

SCOTCAT Credits:	120	SCQF Level 10	**Semester:**	Whole Year
Academic year:	2016/7			
Availability restrictions:	Available to non-graduating students only, by arrangement			
Planned timetable:	No specific hours.			

This module is for non-graduating students who wish to pursue a project in physics lasting the whole session. The project is designed to develop students' skills in searching the literature, in the design of the investigation of the topic, in the evaluation and interpretation of data and in the presentation of results. There is no specific syllabus for this module, and students select their project topic in consultation with their supervisor.

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. There is no guarantee that this project will be available.

Programme module type:	Non-graduating students only.	
Learning and teaching methods and delivery:	**Weekly contact**: As a minimum, weekly meetings with supervisor.	
	Scheduled learning: hours	**Guided independent study:** hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%	
	As used by St Andrews: Coursework (reports, presentation, and oral examination) = 100%	
Module Co-ordinator:	(TBC)	
Lecturer(s)/Tutor(s):	(TBC)	

PH4113 Physics Project (Non-graduating - 60)

SCOTCAT Credits:	60	SCQF Level 10	**Semester:**	1 or 2
Academic year:	2016/7			
Availability restrictions:	Available to non-graduating students only, by arrangement			
Planned timetable:	No specific hours.			

This module is for non-graduating students who wish to pursue a project in physics lasting one semester. The project is designed to develop students' skills in searching the literature, in the design of the investigation of the topic, in the evaluation and interpretation of data and in the presentation of results. There is no specific syllabus for this module, and students select their project topic in consultation with their supervisor.

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. There is no guarantee that this project will be available.

Programme module type:	Non-graduating students only	
Learning and teaching methods and delivery:	**Weekly contact**: Weekly meetings with supervisor.	
	Scheduled learning: hours	**Guided independent study:** hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = %, Coursework = %	
	As used by St Andrews: Coursework (reports, presentation, and oral examination) = 100%	
Module Co-ordinator:	(TBC)	
Lecturer(s)/Tutor(s):	(TBC)	

PH4796 Joint Project (30cr)

SCOTCAT Credits:	30	SCQF Level 10	**Semester:**	TBC
Academic year:	2016/7 ~~& 2017/8~~			
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.	
	Scheduled learning: hours	**Guided independent study:** hours
Assessment pattern:	**As defined by QAA:** Written Examinations = %, Practical Examinations = %, Coursework = %	
	As used by St Andrews: As per Letter of Agreement.	
Re-Assessment pattern:	As per Letter of Agreement.	
Module Co-ordinator:	Dr P King	

PH5002 Foundations of Quantum Mechanics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2016/7 & 2017/8			
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 (TBC)			
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):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]) PH3061 and PH3062.			
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:	2016/7 & 2017/8			
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 (TBC)			
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):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3061 and PH3062.			
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:	2016/7 & 2017/8			
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 (TBC)			
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, 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, and a descriptive introduction to Green's functions and Feynman diagrams.				
Programme module type:	Compulsory for Theoretical Physics Optional for Astrophysics MPhys, Physics MPhys, Chemistry and Physics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]),PH3012, PH3061, PH3062 and PH4038 or MT4507.			
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 = 85%, Practical Examinations = 0%, Coursework = 15%			
	As used by St Andrews: 2-hour Written Examination = 85%, Coursework = 15%			
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:	2016/7 & 2017/8			
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 (TBC)			
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):	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):	Dr L O'Faolain, Dr B Sinclair, Dr T Brown			

PH5011 General Relativity

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2016/7 & 2017/8			
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**			
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):	PH3081 or PH3082, PH3081 or PH3082 or [MT2003 or MT2506 and MT2507)], Recommended PH4038 and PH4032.			
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 M Dominik			
Lecturer(s)/Tutor(s):	Dr M Dominik			

PH5012 Quantum Optics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2016/7 & 2017/8			
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):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3061, PH3062, PH4028.			
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:	2016/7 & 2017/8			
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 (TBC)			

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):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH4039, PH3012, PH3061, PH3062.	
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 C Hooley	
Lecturer(s)/Tutor(s):	Dr C Hooley	

PH5015 Applications of Quantum Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2016/7 & 2017/8			
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 (TBC)			

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):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH3061, PH3062.	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures/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:	2016/7 & 2017/8			
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 (TBC)			
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):	PH2011, PH2012, MT2001 or (MT2501 and MT2503), (PH3081 or PH3082 or [MT2003 or (MT2506 and MT2507)]), PH4034 or PH4035.			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures/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:	2016/7 & 2017/8			
Planned timetable:	**2.00 pm Tue, Fri and 11.00 am Wed**			
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 = 25%, Practical Examinations = 25%, Coursework = 50%			
	As used by St Andrews: Coursework (worksheets = 50%, 3-hour computing test = 25%, 1-hour Class Test = 25%) = 100%			
Re-Assessment pattern:	No Re-Assessment available - laboratory based			
Module Co-ordinator:	Dr K Wood			
Lecturer(s)/Tutor(s):	Dr K Wood			

PH5024 Modern Topics in Condensed Matter Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2016/7 & 2017/8			
Availability restrictions:	Available only to those in the final year of an MPhys programme			
Planned timetable:	10.00 am Tue, Wed, Thu (TBC)			

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 or PH4041), 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:	2016/7 & 2017/8			
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:	2016/7 & 2017/8			
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.

Please note: Some projects will need learning from specific modules - please contact potential supervisors.

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 or PH4040 or PH4041), PH4032.	
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 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	