School of Physics & Astronomy

Modules

Normally the pre-requisite (s) for each of the following Honours modules is entry to the Honours Programme(s) for which they are specified, as well as any additional specific pre-requisite(s) given.

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 before making their selection.

The pre-requisite(s) for each of the following 5000-level modules is entry to the M.Sci. or M.Phys. Programme(s) for which they are specified, save where an additional pre-requisite is given.

Astronomy (AS) Modules

AS3013 Computational Astrophysics

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Planned timetable:	2.00 pm - 5.00 pm Mon and Thu.			
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):	AS2001 or AS2101			
Learning and teaching methods and delivery:	**Weekly contact**: 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%			
Module Co-ordinator:	Dr P Woitke			
Lecturer(s)/Tutor(s):	Dr P Woitke, Dr C Helling			

AS4010 Galaxies and Observational Cosmology

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Planned timetable:	To be arranged.			

This module introduces the basic elements of extragalactic astronomy and observational cosmology. The first half of the module 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 dominated Universe.

The second half of the module starts with Olber's paradox, (why is the sky dark at night?) and its resolution (that the universe had a beginning) and then reviews the evidence that the universe is currently expanding at 68±10 km/s/Mpc. We then develop a mathematical framework capable of dealing with expanding curved space-time and derive the basic equations which govern the expansion and curvature of the universe as a function of time. We test the predictions, strengths and weaknesses of this standard model including the cosmic microwave background, big bang nucleosynthesis and the need for the theory of inflation. We find that the fate of the universe is entirely dependent on the current density of matter, radiation and vacuum energy, and review the latest observations which measure these key parameters.

Finally the ultimate fate of the Universe is revealed.

Programme module type:	Compulsory for Astrophysics B.Sc. and M.Phys. Optional for Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics		
Pre-requisite(s):	AS2001 or AS2101, PH2012	**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 = 100%, Practical Examinations = 0%, Coursework = 0%		
	As used by St Andrews: 2-hour Written Examination = 100%		
Module Co-ordinator:	Dr V Wild		
Lecturer(s)/Tutor(s):	Dr V Wild, Dr H Zhao		

AS4011 The Physics of Nebulae and Stars I

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2013/4 and subsequent years			
Availability restrictions:	Expected to be available each year from 2013/4			
Planned timetable:	To be arranged.			

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 M.Phys. At least 2 of AS4011, AS4012, AS4015, AS4021, AS4025, PH4031 are compulsorys for Astrophysics B.Sc. Optional for Astrophysics, Physics B.Sc. Optional module for Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics M.Phys.		
Pre-requisite(s):	AS2001 or AS2101, PH2012	**Anti-requisite(s):**	AS4023, AS3015
Required for:	AS4012 The Physics of Nebulae and Stars 2		
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: Coursework = 25%, 2-hour Written Examination = 75%		
Module Co-ordinator:	Dr K Wood		
Lecturer(s)/Tutor(s):	Dr K Wood, Prof A C Cameron		

AS4012 The Physics of Nebulae and Stars 2

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2013/4 and subsequent years			
Availability restrictions:	Expected to be available each year from 2013/4			
Planned timetable:	To be arranged.			

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 M.Phys. At least 2 of AS4011, AS4012, AS4015, AS4021, AS4025, PH4031 are compulsorys for Astrophysics B.Sc. Optional for Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics		
Pre-requisite(s):	AS4011 The Physics of Nebulae and Stars I	**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: Coursework = 25%, 2-hour Written Examination = 75%		
Module Co-ordinator:	Dr K Wood		
Lecturer(s)/Tutor(s):	Dr K Wood		

AS4015 Gravitational and Accretion Physics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2013/4 and subsequent years			
Availability restrictions:	Expected to be available each year from 2013/4			
Planned timetable:	To be arranged.			
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 M.Phys. At least 2 of AS4011, AS4012, AS4015, AS4021, AS4025, PH4031 are compulsory for Astrophysics B.Sc. Optional for Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011		**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%			
Module Co-ordinator:	Dr H Zhao			
Lecturer(s)/Tutor(s):	Dr H Zhao, Prof K D Horne			

AS4021 Gravitational Dynamics

SCOTCAT Credits:	10	SCQF Level 10	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	This module will run for the final time in 2012/3, and is intended for students who started their honours programme in the School in 2011 or before.			
Planned timetable:	To be arranged.			
This module aims to explore the basics of gravitational dynamics and its application to systems ranging from planetary and stellar systems to clusters of galaxies. 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 self-gravitating 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:	Optional for Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics For students who started their Honours programmes in 2011 or before, please refer to previous Course Catalogues.			
Pre-requisite(s):	AS2001 or AS2101			
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and some tutorials.			
	Scheduled learning: 20 hours		**Guided independent study:** 80 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%			
Module Co-ordinator:	Prof I A Bonnell			
Lecturer(s)/Tutor(s):	Prof I A Bonnell			

AS4022 Cosmology

SCOTCAT Credits:	10	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Availability restrictions:	This module will run for the final time in 2012/3, and is intended for students who started their honours programme in the School in 2011 or before.			
Planned timetable:	To be arranged.			

The module starts with Olber's paradox, (why is the sky dark at night?) and its resolution (that the universe had a beginning) and then reviews the evidence that the universe is currently expanding at 68110 km/s/Mpc. We then develop a mathematical framework capable of dealing with expanding curved space-time and derive the basic equations which govern the expansion and curvature of the universe as a function of time. We test the predictions, strengths and weaknesses of this standard model including the cosmic microwave background, big bang nucleosynthesis and the need for the theory of inflation. We find that the fate of the universe is entirely dependent on the current density of matter, radiation and vacuum energy, and review the latest observations which measure these key parameters. Finally the ultimate fate of the Universe is revealed.

Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics For students who started their Honours programmes in 2011 or before, please refer to previous Course Catalogues.		
Pre-requisite(s):	AS2001 or AS2101	**Anti-requisite(s):**	AS4010
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures per week and some tutorials.		
	Scheduled learning: 22 hours	**Guided independent study:** 78 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%		
	As used by St Andrews: 2-hour Written Examination = 100%		
Module Co-ordinator:	Dr H Zhao		
Lecturer(s)/Tutor(s):	Dr H Zhao		

AS4023 Stars

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Availability restrictions:	This module will run for the final time in 2012/13, and is intended for students who started their honours programme in the School in 2011 or before.			
Planned timetable:	To be arranged.			
This module develops the physics of stellar interiors and atmospheres from the basic equations of stellar structure introduced in AS2001. Topics include: the equation of state that provides pressure support at the high temperatures and densities found in normal and white-dwarf stars; the interaction of radiation with matter, both in terms of radiation-pressure support in super-massive stars and in terms of the role of opacity in controlling the flow of energy from the stellar interior to the surface; the equation of radiative transfer and the effects of local temperatures, pressures and velocity fields on the continuum and line absorption profiles in the emergent spectrum. Computer-aided tutorial exercises illustrate the computational schemes that represent one of the triumphs of late 20th-century physics, in their ability to predict the observable properties of a star from its radius and luminosity, which in turn are determined by its mass, age and chemical composition.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics For students who started their Honours programmes in 2011 or before, please refer to previous Course Catalogues.			
Pre-requisite(s):	AS2001 or AS2101		**Anti-requisite(s):**	AS4011, AS4012
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures occasionally replaced by whole-group 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%			
Module Co-ordinator:	Prof A C Cameron			
Lecturer(s)/Tutor(s):	Prof A C Cameron, Dr K Wood			

AS4025 Observational Astrophysics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2012/3			
Planned timetable:	To be arranged.			

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 B.Sc. Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics	
Pre-requisite(s):	AS2001 or AS2101	
Learning and teaching methods and delivery:	**Weekly contact**: 2 x 3 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%	
Module Co-ordinator:	Prof A C Cameron	
Lecturer(s)/Tutor(s):	Dr J Greaves, Dr P A S Cruickshank, Prof A C Cameron	

AS4103 Astrophysics Project (B.Sc.)

SCOTCAT Credits:	30	SCQF Level 10	**Semester:**	Whole Year
Academic year:	2012/3			
Availability restrictions:	Available only to B.Sc. Astrophysics students, and normally only in their final year.			
Planned timetable:	Please Contact School			

The project aims to develop students' skills in searching the appropriate literature, in experimental and observational design, the evaluation and interpretation of data, and the presentation of a report. The main project is preceded by a review essay. There is no specific syllabus for this module. Students taking the BSc degree select a project from a list of those which are available, and are supervised by a member of the academic staff. Project choice and some preparatory work is undertaken in semester one, but around 29 of the 30 credits' worth of work is normally 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 computing clusters, but other arrangements are possible. The review essay that precedes the observational/computational work is worth 10 credits, i.e. should have about 100 hours of work invested in it. This work is expected to be directly useful to the subsequent studies.

Programme module type:	Compulsory for Astrophysics B.Sc.	
Anti-requisite(s):	AS5101, PH4111, PH5101, PH5102	
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 and Oral Examination) = 100%	
Module Co-ordinator:	Prof M M Jardine	
Lecturer(s)/Tutor(s):	Astronomy staff	

AS5001 Advanced Data Analysis

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	This module is intended for students in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			

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 must be taken for M.Phys. Astrophysics Optional for Physics M.Phys., 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 M.Phys. programme or entry to a taught postgraduate 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%	
Module Co-ordinator:	Prof K D Horne	
Lecturer(s)/Tutor(s):	Prof K D Horne	

AS5002 Magnetofluids and Space Plasmas

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	This module is intended for students in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
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 M.Phys. Astrophysics Optional for Physics M.Phys., Theoretical Physics, Theoretical Physics and Mathematics			
Pre-requisite(s):	(PH2012 or MT3601), (PH3075 or MT2003), PH4031 is strongly recommended. Entry to an M.Phys. Programme or a taught postgraduate programme in the School.			
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%			
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:	2012/3			
Availability restrictions:	Available only to M.Phys. Astronomy students or a taught postgraduate programme in the School.			
Planned timetable:	To be arranged.			
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 must be taken for M.Phys. Astrophysics			
Pre-requisite(s):	Entry to M.Phys. Astronomy programme. (AS2001 or AS2101), AS3011 or AS4010 and AS3012 or AS4015 recommended			
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%			
Module Co-ordinator:	Dr C Helling			
Lecturer(s)/Tutor(s):	Dr C Helling, Dr A Vidotto, Dr S Gregory			

AS5101 Astrophysics Project (M.Phys.)

SCOTCAT Credits:	60	SCQF Level 11	**Semester:**	Whole Year
Availability restrictions:	Available only to final year M.Phys. Astronomy students			
Planned timetable:	Please Contact School			
The project aims to develop students' skills in searching the appropriate literature, in experimental and observational design, the evaluation and interpretation of data, and the presentation of a report. The main project is preceded by a review essay. There is no specific syllabus for this module. Students taking the M. Phys. 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. The review essay that precedes experimental work is worth 10 credits, ie should have about 100 hours of work invested in it. This work is expected to be directly useful to the subsequent studies.				
Programme module type:	Compulsory for Astrophysics M.Phys.			
Anti-requisite(s):	AS4103, PH4111, PH5101, PH5102			
Learning and teaching methods and delivery:	**Weekly contact**: Project students work "full-time" on their M.Phys. 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%			
Module Co-ordinator:	Prof M M Jardine			

Physics (PH) Modules

PH3007 Electromagnetism

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Planned timetable:	To be arranged.			
The properties of electric and magnetic fields will be discussed, starting with static fields and moving on to time-dependent properties. Maxwell's equations are derived, and result in the wave equation and the conclusion that light is an electromagnetic wave. The theory is applied to the transmission of waves in free space, waveguides and transmission lines, metals and dielectrics. The relation between electromagnetic theory and quantum theory will be discussed briefly.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics, Physics and Chemistry M.Sci.,Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	(PH3081 or PH3075 or MT2003) and PH2012 and MT2001.			
Required for:	PH4025, PH4027, PH5005, PH5018, PH5021			
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: Coursework = 20%, 2-hour Written Examination = 80%			
Module Co-ordinator:	Dr G M Smith			
Lecturer(s)/Tutor(s):	Dr G M Smith			

PH3012 Thermal and Statistical Physics

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Academic year:	2012/3			
Planned timetable:	To be arranged.			
The aim of this module is to cover at honours level the principles and most important applications of thermodynamics and statistical mechanics. The syllabus includes: derivation of the three laws of thermodynamics, and the equation of state; Maxwell's relations; correction of solid state results from constant pressure to constant volume, liquifaction of gases; concept of independent quantum state; energy levels and degeneracy; the microcanonical ensemble; quantum gases and the classical limit; the canonical ensemble; fluctuations; the connection with thermodynamics; the classical perfect gas; equipartition of energy; the grand canonical ensemble; black body radiation; matter at high density and pressure; fluctuations and noise; phase transitions; negative temperatures.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics, Chemistry and Physics M.Sci., Physics and Mathematics, Theoretical Physics and Mathematics			
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: Coursework = 20%, 2-hour Written Examination = 80%			
Module Co-ordinator:	Dr P A S Cruickshank			
Lecturer(s)/Tutor(s):	Dr P A S Cruickshank, Prof Steve Lee			

PH3014 Transferable Skills for Physicists

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	Whole Year
Academic year:	2012/3			
Planned timetable:	To be arranged.			
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):	Entry to the School's Honours programme, or shadowing same.			
Anti-requisite(s):	PH4040			
Learning and teaching methods and delivery:	**Weekly contact**: Occasional lectures or tutorials or workshops.			
	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%			
Module Co-ordinator:	Dr B D Sinclair			
Lecturer(s)/Tutor(s):	Physics and Astronomy staff			

PH3061 Quantum Mechanics 1

SCOTCAT Credits:	10	SCQF Level 9	**Semester:**	1
Academic year:	2012/3			
Planned timetable:	To be arranged.			
This module introduces the main features of quantum mechanics. The syllabus includes: early ideas on quantisation, the emergence of the Schrödinger equation, the interpretation of the wave function and Heisenberg's uncertainty relation. The concepts of eigenfunctions and eigenvalues. Simple one-dimensional problems including potential wells and barriers; the linear harmonic oscillator. Solution of the Schrödinger equation for central forces, the radial Schrödinger equation, and the hydrogen atom.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics, Chemistry and Physics M.Sci., Physics and Mathematics, Theoretical Physics and Mathematics			
Required for:	PH3062, PH4021, PH4022, PH4025, PH4028, PH4037, PH4040, PH5002, PH5003, PH5004, PH5005, PH5012, PH5014, PH5015, PH5021			
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: Coursework = 20%, 2-hour Written Examination = 80%			
Module Co-ordinator:	Dr A S Kohnle			
Lecturer(s)/Tutor(s):	Dr A S Kohnle			

PH3062 Quantum Mechanics 2

SCOTCAT Credits:	10	SCQF Level 9	**Semester:**	2
Academic year:	2012/3			
Planned timetable:	To be arranged.			
This module explores more of the main features of quantum mechanics, taking for granted a knowledge of the material in PH3061. The syllabus includes a treatment of perturbation theory, and time dependence of the wave function including transitions between stationary states. Students are introduced to the quantum mechanics of a system of particles, which leads on to the distinction between fermions and bosons and applications to atoms, metals and neutron stars.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics, Chemistry and Physics M.Sci., Physics and Mathematics, Theoretical Physics and Mathematics			
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 some 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: Coursework = 20%, 2-hour Written Examination = 80%			
Module Co-ordinator:	Dr D Cassettari			
Lecturer(s)/Tutor(s):	Dr D Cassettari			

PH3073 Lagrangian and Hamiltonian Dynamics

SCOTCAT Credits:	10	SCQF Level 9	**Semester:**	2
Academic year:	2012/3			
Availability restrictions:	This module runs under this code for the final time in 2012-13. It is intended for those who started their honours programme in the School in 2011-12 or before.			
Planned timetable:	To be arranged.			
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 planetary motion, particle scattering, oscillators, and chaos.				
Programme module type:	Compulsory for all M.Phys. degrees, except Mathematics and Theoretical Physics PH3073 or MT4507 is a compulsory for Mathematics and Theoretical Physics			
Pre-requisite(s):	PH2011, MT2001 and a knowledge of vector calculus.		**Anti-requisite(s):**	MT4507, PH4038
Required for:	PH4032 (unless MT4507 is taken), PH5004			
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and some tutorials.			
	Scheduled learning: 26 hours		**Guided independent study:** 74 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 75%, Practical Examinations = 0%, Coursework = 25%			
	As used by St Andrews: Coursework = 25%, 2-hour Written Examination = 75%			
Module Co-ordinator:	Dr N Korolkova			
Lecturer(s)/Tutor(s):	Dr N Korolkova			

PH3074 Electronics

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	1
Academic year:	2012/3			
Planned timetable:	To be arranged.			
This module gives a basic grounding in practical electronics. It introduces and develops the basic principles underlying the synthesis and analysis of digital and analogue circuits. The module is divided into three parts: an introductory section which reviews those parts of electromagnetism most related to electronics, including d.c. and a.c. circuit theory; a section on transistors and amplifiers including simple transistor circuits and noise considerations; and a section on digital electronics including logic gates, flip-flops and the design of circuits with applications to counters, latches registers etc.				
Programme module type:	Compulsory for Materials Chemistry B.Sc. and M.Chem., Physics M.Phys. Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures, tutorials or short lab sessions			
	Scheduled learning: 36 hours		**Guided independent study:** 114 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 75%, Practical Examinations = 0%, Coursework = 25%			
	As used by St Andrews: Coursework = 25%, 2-hour Written Examination = 75%			
Module Co-ordinator:	Dr P A S Cruickshank			
Lecturer(s)/Tutor(s):	Dr P A S Cruickshank			

PH3080 Computational Physics

SCOTCAT Credits:	10	SCQF Level 9	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	This module is intended for students who started their honours programme in the School in 2012-13 and later.			
Planned timetable:	To be arranged.			
This module is designed to develop a level of competence in Mathematica, a modern programming language currently used in many physics research labs for mathematical modelling. No prior experience is required. The module starts with a grounding in the use of Mathematica and discusses symbolic solutions and numerical methods. The main focus will be the use of Mathematica for problem solving in physics. The module is continually assessed through short tests and assignments, with the bulk of the assessment based on the submission of a Mathematica project.				
Programme module type:	Compulsory for Astrophysics, Single and Joint Honours Physics, Theoretical Physics This or one of the computational maths modules is compulsory for the joint degrees with Mathematics.			
Anti-requisite(s):	PH4030			
Learning and teaching methods and delivery:	**Weekly contact**: 2 x 2 - 2.5-hour sessions 1 week followed by 1 x 2 - 2.5-hour session the following week. This pattern alternates over the semester.			
	Scheduled learning: 44 hours		**Guided independent study:** 56 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%			
	As used by St Andrews: Coursework = 100%			
Module Co-ordinator:	Dr A D Gillies			
Lecturer(s)/Tutor(s):	Dr A D Gillies, Dr G M Smith, Dr M Mazilu			

PH3081 Mathematics for Physicists

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	1
Academic year:	2012/3			
Planned timetable:	To be arranged.			

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 gamma function, 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):	PH2012, MT2001	**Anti-requisite(s):**	PH3066, PH3075, PH3082
Required for:	PH3007, PH5011 unless other pre-requisite(s) 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: Coursework (Class Tests) = 20%, 2-hour Written Examination = 80%		
Module Co-ordinator:	Dr C Hooley		
Lecturer(s)/Tutor(s):	Dr C Hooley		

PH3082 Mathematics for Chemistry / Physics

SCOTCAT Credits:	20	SCQF Level 9	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Available only to Chemistry and Physics M.Sci. students			
Planned timetable:	To be arranged.			

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 gamma function, 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 M.Sci.		
Pre-requisite(s):	PH2012, MT2001	**Anti-requisite(s):**	PH3066, PH3081
Required for:	PH5011 unless other pre-requisite(s) taken		
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures per week plus tutorials and computing lab sessions.		
	Scheduled learning: 62 hours	**Guided independent study:** 138 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 75%, Practical Examinations = 0%, Coursework = 25%		
	As used by St Andrews: Coursework = 40%, 2-hour Written Examination = 60%		
Module Co-ordinator:	Dr C Hooley		
Lecturer(s)/Tutor(s):	Dr C Hooley, Dr A Gillies, Dr G M Smith, Dr M Mazilu		

PH3101 Physics Laboratory 1

SCOTCAT Credits:	15	SCQF Level 9	**Semester:**	2
Academic year:	2012/3			
Planned timetable:	2.00 pm - 5.30 pm Mon and 2.00 pm - 5.30 pm Thu.			
The aims of the module are (i) to familiarise students with a wide variety of experimental techniques and equipment, and (ii) to instill an appreciation of the significance of experiments and their results. The module consists of sub-modules on subjects such as solid state physics, lasers, interfacing, and signal processing and related topics.				
Programme module type:	Compulsory for Physics B.Sc. and M.Phys., Chemistry and Physics M.Sci. Optional for Astrophysics, Physics and Mathematics, Theoretical Physics and Mathematics			
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%			
Module Co-ordinator:	Dr C F Rae			
Lecturer(s)/Tutor(s):	Dr C F Rae and Physics staff			

PH4021 Physics of Atoms

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	This module will run for the final time in 2012/3, and is intended for students who started their honours programme in the School in 2011/2 or before.			
Planned timetable:	To be arranged.			
This module provides a rational basis to the identification of atomic energy states and the various interactions of electrons within atoms. It provides an understanding of aspects of laser physics, solid state and stellar physics. The syllabus includes: electron cloud model of an atom; electron spin; magnetic moments of electron behaviour; spin-orbit interactions and possible states of electron energy; one and two-electron systems; line intensities; Lande g-factors; weak Zeeman and strong Paschen-Back magnetic field effects; Stark electric field effects; hyperfine structure and Lamb shifts; magnetic resonance and esr in atomic beam experiments; molecular structure: electronic, vibrational and rotational effects.				
Programme module type:	Compulsory for Physics, Theoretical Physics, Chemistry and Physics			
Pre-requisite(s):	PH3061, PH3062			
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%			
Module Co-ordinator:	Dr D Cassettari			
Lecturer(s)/Tutor(s):	Dr D Cassettari			

PH4022 Nuclear and Particle Physics

SCOTCAT Credits:	10	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Availability restrictions:	This module will run for the final time in 2012/3, and is intended for students who started their honours programme in the School in 2011/2 or before.			
Planned timetable:	To be arranged.			
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 M.Sci., Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2012, 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 = 95%, Practical Examinations = 0%, Coursework = 5%			
	As used by St Andrews: Coursework = 5%, 2-hour Written Examination = 95%			
Module Co-ordinator:	Dr A S Kohnle			
Lecturer(s)/Tutor(s):	Dr A S Kohnle			

PH4025 Physics of Electronic Devices

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Planned timetable:	To be arranged.			
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):	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%			
Module Co-ordinator:	Dr G A Turnbull			
Lecturer(s)/Tutor(s):	Dr G A Turnbull			

PH4026 Signals and Information

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Planned timetable:	To be arranged.			
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)			
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%			
Module Co-ordinator:	Dr P A S Cruickshank			
Lecturer(s)/Tutor(s):	Dr P A S Cruickshank			

PH4027 Optoelectronics and Nonlinear Optics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2012/3			
Planned timetable:	To be arranged.			
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):	PH3007			
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%			
Module Co-ordinator:	Prof I D W Samuel			
Lecturer(s)/Tutor(s):	Prof I D W Samuel, Dr Ml Mazilu			

PH4028 Advanced Quantum Mechanics

SCOTCAT Credits:	10	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Planned timetable:	To be arranged.			
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. Matrix mechanics is introduced as it is a convenient formalism in the applications of operator methods. These ideas are then used to cover the density matrix formalism as the general state description. Quantum degenerate gases will be discussed, including Bose-Einstein condensates and degenerate fermionic gases. Quantum information concepts will be covered, including concepts such as quantum entanglement, qubits, quantum telephoration, and quantum key distribution.				
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			
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and some tutorials.			
	Scheduled learning: 22 hours		**Guided independent study:** 78 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 2-hour Written Examination = 100%			
Module Co-ordinator:	Dr N Korolkova			
Lecturer(s)/Tutor(s):	Dr N Korolkova, Dr D Cassettari			

PH4030 Computational Physics

SCOTCAT Credits:	10	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Availability restrictions:	This module will run for the final time in 2012/13, and is intended for students who started their honours programme in the School in 2011/12 or before.			
Planned timetable:	To be arranged.			
This module is designed to develop a level of competence in Mathematica, a modern programming language currently used in many physics research labs for mathematical modelling. No prior experience is required. The module starts with a grounding in the use of Mathematica and discusses symbolic solutions and numerical methods. The main focus will be the use of Mathematica for problem solving in physics. The module is continually assessed through short tests and assignments, with the bulk of the assessment based on the submission of a Mathematica project.				
Programme module type:	This module is compulsory to students completing existing M.Phys. programmes in Physics and Theoretical Physics only.			
Anti-requisite(s):	PH3080			
Learning and teaching methods and delivery:	**Weekly contact**: 2 x 2-hour sessions.			
	Scheduled learning: 44 hours		**Guided independent study:** 56 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%			
	As used by St Andrews: Coursework = 100%			
Module Co-ordinator:	Dr G M Smith			
Lecturer(s)/Tutor(s):	Dr G M Smith, Dr A D Gillies, Dr Ml Mazilu			

PH4031 Fluids

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Planned timetable:	To be arranged.			
This module provides an introduction to fluid dynamics, and addresses the underlying physics behind many everyday flows that we see around us. It starts from a derivation of the equations of hydrodynamics and introduces the concept of vorticity and the essentials of vorticity dynamics. The influence of viscosity and the formation of boundary layers is described with some straightforward examples. The effect of the compressibility of a fluid is introduced and applied to shock formation and to the conservation relations that describe flows through shocks. A simple treatment of waves and instabilities then allows a comparison between theory and readily-observed structures in clouds, rivers and shorelines.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics Two of PH4031, AS4011, AS4012, AS4025, AS4015 compulsory for Astrophysics B.Sc. Two of PH4031, AS4025, AS4015 compulsory for Astrophysics M.Phys.			
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%			
Module Co-ordinator:	Prof M M Jardine			
Lecturer(s)/Tutor(s):	Prof M M Jardine			

PH4032 Special Relativity and Fields

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:				
Planned timetable:	To be arranged.			
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):	PH3073 or MT4507			
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: Coursework (assessed tutorial questions) = 25%, 2-hour Written Examination = 75%			
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:	2012/3			
Planned timetable:	To be arranged.			
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			
Required for:	PH5016 (unless PH4035 is taken), PH5018 - 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: Coursework = 10%, 2-hour Written Examination = 90%			
Module Co-ordinator:	Dr F E W Koenig			
Lecturer(s)/Tutor(s):	Dr F E W Koenig			

PH4035 Principles of Optics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Planned timetable:	To be arranged.			
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			
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: Coursework = 25%, 2-hour Written Examination = 75			
Module Co-ordinator:	Dr F E W Koenig			
Lecturer(s)/Tutor(s):	Dr F E W Koenig			

PH4036 Physics of Music

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2012/3			
Planned timetable:	To be arranged.			
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. Analogue and digital recording and playback technology are other topics of interest which will be described.				
Programme module type:	Optional for Astrophysics, Physics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	Admission to an Honours class in the School of Physics and Astronomy and prior or concurrent attendance at PH3066			
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%			
Module Co-ordinator:	Dr J A Kemp			
Lecturer(s)/Tutor(s):	Dr J A Kemp			

PH4037 Physics of Atoms

SCOTCAT Credits:	10	SCQF Level 10	**Semester:**	1
Academic year:	2013/4 and subsequent years.			
Availability restrictions:	This module is expected to run every year from 2013/14, and is intended for students who started their honours programme in the School in 2012/13 and later.			
Planned timetable:	To be arranged.			
This module provides a rational basis to the identification of atomic energy states and the various interactions of electrons within atoms. The syllabus includes: electron cloud model of an atom; electron spin and magnetic moment; spin-orbit interactions; one, two and many-electron systems; selection rules and line intensities for electric-dipole transitions; Lande g-factors; weak Zeeman and strong Paschen-Back magnetic field effects; hyperfine structure and Lamb shifts.				
Programme module type:	Compulsory for Physics, Astrophysics, Theoretical Physics, Chemistry and Physics M.Sci. Optional for Physics and Mathematics, Theoretical Physics and Mathematics			
Pre-requisite(s):	PH3061, PH3062		**Anti-requisite(s):**	PH4021
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
	Scheduled learning: 22 hours		**Guided independent study:** 78 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: Written Examination = 100%			
Module Co-ordinator:	Dr D Cassettari			
Lecturer(s)/Tutor(s):	Dr D Cassettari			

PH4038 Lagrangian and Hamiltonian Dynamics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	2
Academic year:	2012/3			
Availability restrictions:	This module is intended for students who started their honours programme in the School in 2012/13 and later.			
Planned timetable:	To be arranged.			
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 planetary motion, particle scattering, oscillators, and chaos.				
Programme module type:	Compulsory for Astrophysics M.Phys., Physics M.Phys., Theoretical Physics Optional for Astrophysics B.Sc., Chemistry and Physics M.Sci., Physics B.Sc., Physics and Mathematics One of PH4038 and MT4507 compulsory for Theoretical Physics and Mathematics			
Pre-requisite(s):	PH2011, MT2001 and a knowledge of vector calculus.			
Anti-requisite(s):	MT4507, PH3073			
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%			
Module Co-ordinator:	Dr N Korolkova			
Lecturer(s)/Tutor(s):	Dr N Korolkova			

PH4039 Solid State Physics

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	This module is intended normally to be taken in the SH year of the School's programmes. In 2012/13 only those on the Materials Chemistry programme (and a few other joint degree students) are expected to take this module.			
Planned timetable:	To be arranged.			
This module is intended to show how the various optical, thermal and electrical properties of solids are related to the nature and arrangement of the constituent atoms in a solid. For simplicity, emphasis is given to crystalline solids. The module examines: symmetry properties of crystals; common crystalline structures; the behaviour of waves in crystals; waves of atomic motion, leading to thermal properties; electronic energy states: conductors, insulators, semiconductors; electrical properties arising from the wave nature of electrons; examples of the fundamental theory to typical solids such as simple metals, silicon and other semiconductors, and magnetic materials.				
Programme module type:	Compulsory for Materials Chemistry B.Sc. and M.Chem. Compulsory for Physics, Theoretical Physics, Chemistry and Physics M.Sci., Physics and Mathematics, Theoretical Physics and Mathematics			
Anti-requisite(s):	PH3002			
Required for:	PH5014 (unless PH3002 was taken under previous requirements)			
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: Coursework = 20%, 2-hour Written Examination = 80%			
Module Co-ordinator:	Prof S L Lee			
Lecturer(s)/Tutor(s):	Prof S L Lee			

PH4040 Nuclear and Particle Physics (Extended)

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2013/4 and subsequent years.			
Availability restrictions:	Available only to students on the Physics and Logic and Philosophy of Science, and Physics and Computer Science programmes. The module is expected to run every year from 2013/14.			
Planned timetable:	To be arranged.			
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, and Physics and Computer Science			
Pre-requisite(s):	PH3061, PH3062, Entry to B.Sc. Honours in either Logic and Philosophy of Science and Physics or Computer Science and Physics			
Anti-requisite(s):	PH4022, PH3014			
Learning and teaching methods and delivery:	**Weekly contact**: Weekly lectures and occasional workshops and tutorials.			
	Scheduled learning: 32 hours		**Guided independent study:** 118 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 60%, Practical Examinations = 0%, Coursework = 40%			
	As used by St Andrews: Coursework = 40%, 2-hour Written Examination = 60%			
Module Co-ordinator:	Dr A S Kohnle			
Lecturer(s)/Tutor(s):	Dr A S Kohnle, Dr B D Sinclair			

PH4105 Physics Laboratory 2

SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Academic year:	2012/3			
Planned timetable:	2.00 pm - 5.30 pm Mon and 2.00 pm - 5.30 pm Thu.			
The aims of the module are (i) to familiarise students with a wide variety of experimental techniques and equipment, and (ii) to instil an appreciation of the significance of experiments and their results. The module consists of sub-modules on topics such as solid state physics, optics, interfacing, and signal processing.				
Programme module type:	Compulsory for Physics Optional for Astrophysics, Theoretical Physics, Physics and Mathematics, Theoretical Physics and Mathematics			
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%			
Module Co-ordinator:	Dr C F Rae			
Lecturer(s)/Tutor(s):	Dr C F Rae and Physics staff			

PH4111 Physics Project (B.Sc.)

SCOTCAT Credits:	30	SCQF Level 10	**Semester:**	Whole Year
Academic year:	2012/3			
Availability restrictions:	Normally only in the final year of a Physics B.Sc. programme			
Planned timetable:	Please Contact School			

The project aims to develop students' skills in searching the physics literature and in experimental design, the evaluation and interpretation of data, and in the presentation of results. The main project is preceded by a review essay on a topic which is usually related to the theme of the project. There is no specific syllabus for this module. Students taking the B.Sc. 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. The review essay that precedes experimental work is worth 10 credits, ie should have about 100 hours of work invested in it. This work is expected to be directly useful to the subsequent experimental studies.

Programme module type:	Compulsory for Single and Joint Honours Physics B.Sc.	
Pre-requisite(s):	At least one of PH3101, PH4105	
Anti-requisite(s):	AS4103, AS5101, PH5101, PH5102	
Learning and teaching methods and delivery:	**Weekly contact** Project students work "half-time" on their project through semester two. 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 = 100%, Coursework = 0%	
	As used by St Andrews: Coursework (Review essay, Report and Oral Examination) = 100%	
Module Co-ordinator:	Dr D Cassettari	
Lecturer(s)/Tutor(s):	Dr D Cassettari and School staff	

PH4112 Physics Project (Non-graduating - 120)

SCOTCAT Credits:	120	SCQF Level 10	**Semester:**	Whole Year
Academic year:	2012/3			
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.
Assessment pattern:	**As used by St Andrews:** Coursework (reports, presentation, and oral examination) = 100%
Module Co-ordinator:	Dr D Cassettari
Lecturer(s)/Tutor(s):	Dr D Cassettari

PH4113 Physics Project (Non-graduating - 60)

SCOTCAT Credits:	60	SCQF Level 10	**Semester:**	Either
Academic year:	2012/3			
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.
Assessment pattern:	**As used by St Andrews:** Coursework (reports, presentation, and oral examination) = 100%
Module Co-ordinator:	Dr D Cassettari
Lecturer(s)/Tutor(s):	Dr D Cassettari

PH5002 Foundations of Quantum Mechanics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
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:	Compulsory for Theoretical Physics, Theoretical Physics and Mathematics Optional for Astrophysics M.Phys., Physics M.Phys., Chemistry and Physics M.Sci.			
Pre-requisite(s):	PH3061 and PH3062, unless you are on a taught postgraduate programme.			
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%			
Module Co-ordinator:	Dr K K Wan			
Lecturer(s)/Tutor(s):	Dr K K Wan			

PH5003 Group Theory

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
This module explores the concept of a group, including groups of coordinate transformations in three-dimensional Euclidean space; the invariance group of the Hamiltonian operator; the structure of groups: subgroups, classes, cosets, factor groups, isomorphisms and homorphisms, direct product groups; introduction to Lie groups, including notions of connectness, compactness, and invariant integration; representation theory of groups, including similarity transformations, unitary representations, irreducible representations, characters, direct product representations, and the Wigner-Eckart theorem; applications to quantum mechanics, including calculation of energy eigenvalues and selection rules.				
Programme module type:	Optional for Astrophysics M.Phys., Physics M.Phys., Theoretical Physics, Chemistry and Physics M.Sci., Theoretical Physics and Mathematics M.Phys.			
Pre-requisite(s):	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%			
Module Co-ordinator:	Prof J F Cornwell			
Lecturer(s)/Tutor(s):	Prof J F Cornwell			

PH5004 Quantum Field Theory

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
This module presents an introductory account of the ideas of quantum field theory and of simple applications thereof, including quantization of classical field theories, second quantization of bosons and fermions, the failure of single particle interpretation of relativistic quantum mechanics, solving simple models using second quantization, Feynman's path integral approach to quantum mechanics and its relation to classical action principles, field integrals for bosons and fermions, the relationship between path integral methods and second quantization, and a descriptive introduction to Feynman Diagrams in quantum field theory and many-body physics.				
Programme module type:	Compulsory for Theoretical Physics and Theoretical Physics and Mathematics Optional for Astrophysics M.Phys., Physics M.Phys., Chemistry and Physics M.Sci.			
Pre-requisite(s):	PH3061, PH3062 and PH3073 or MT4507. PH5002 recommended.			
Co-requisite(s):	PH5002 is recommended but not compulsory.			
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 = 90%, Practical Examinations = 0%, Coursework = 10%			
	As used by St Andrews: 2-hour Written Examination = 90%, Coursework = 10%			
Module Co-ordinator:	Dr J M J Keeling			
Lecturer(s)/Tutor(s):	Dr J M J Keeling			

PH5005 Laser Physics 2

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
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 M.Phys., Physics M.Phys., Theoretical Physics, Chemistry and Physics M.Sci.,Theoretical Physics and Mathematics			
Pre-requisite(s):	PH3007, PH3061 and PH3062. PH4034 is recommended.			
Anti-requisite(s):	PH5018, PH5180			
Learning and teaching methods and delivery:	**Weekly contact**: 4 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: 2.5-hour (open notes) Examination = 100%			
Module Co-ordinator:	Dr B D Sinclair			
Lecturer(s)/Tutor(s):	Dr B D Sinclair, Prof T F Krauss, Prof M H Dunn, Prof W Sibbett			

PH5011 General Relativity

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			

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 M.Phys., Physics M.Phys., Theoretical Physics, Chemistry and Physics M.Sci.,Theoretical Physics and Mathematics	
Pre-requisite(s):	PH3066 or PH3081 or PH3082, PH3075 or PH3081 or PH3082 or MT2003, Recommended PH3073 and PH4032, unless you are on a taught postgraduate 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%	
Module Co-ordinator:	Dr H Zhao	
Lecturer(s)/Tutor(s):	Dr H Zhao	

PH5012 Quantum Optics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
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 M.Phys., Physics M.Phys., Theoretical Physics, Chemistry and Physics M.Sci.,Theoretical Physics and Mathematics			
Pre-requisite(s):	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%			
Module Co-ordinator:	Dr N Korolkova			
Lecturer(s)/Tutor(s):	Dr N Korolkova, Dr F E W Koenig			

PH5014 The Interacting Electron Problem in Solids

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
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 M.Phys., Physics M.Phys., Theoretical Physics, Chemistry and Physics M.Sci.,Theoretical Physics and Mathematics			
Pre-requisite(s):	PH3002 or 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%			
Module Co-ordinator:	Prof A P Mackenzie			
Lecturer(s)/Tutor(s):	Prof A P Mackenzie			

PH5015 Applications of Quantum Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
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 M.Phys., Physics M.Phys., Theoretical Physics, Chemistry and Physics M.Sci.,Theoretical Physics and Mathematics			
Pre-requisite(s):	PH3061, PH3062			
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 = 80%, Practical Examinations = 0%, Coursework = 20%			
	As used by St Andrews: Coursework = 20%, 2-hour Written Examination = 80%			
Module Co-ordinator:	Prof K Dholakia			
Lecturer(s)/Tutor(s):	Prof K Dholakia, Dr Ml Mazilu			

PH5016 Biophotonics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally only taken in the final year of an M.Phys. or M.Sci. programme involving the School			
Planned timetable:	To be arranged.			
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 M.Phys., Physics M.Phys., Theoretical Physics, Chemistry and Physics M.Sci.,Theoretical Physics and Mathematics			
Pre-requisite(s):	PH4034 or PH4035			
Learning and teaching methods and delivery:	**Weekly contact**: 2 lectures and some tutorials.			
	Scheduled learning: 24 hours		**Guided independent study:** 126 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinationss = 0%, Coursework = 20%			
	As used by St Andrews: Coursework = 20%, 2-hour Written Examination = 80%			
Module Co-ordinator:	Prof K Dholakia			
Lecturer(s)/Tutor(s):	Prof K Dholakia, Prof T F Krauss			

PH5022 Organic Semiconductors and Liquid Crystal Displays

SCOTCAT Credits:	10	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	Normally final year of M.Chem. Materials Chemistry programme			
Planned timetable:	To be arranged.			
This "distance-learning" module describes the materials science and device physics that underpins modern display technologies. The module is delivered in a distance learning format. The syllabus includes a basic introduction to vector calculus for materials science and an overview of types of displays and characterisation of display properties. The module then focuses on two contemporary display technologies: liquid crystals and organic semiconductors. Topics covered include: semiconducting polymers; photoluminescence and electroluminescence; organic light-emitting diodes; liquid crystals phases; director, order-parameter and distortions; anisotropy and birefringence; operation of twisted nematic displays.				
Programme module type:	Optional for Materials Chemistry			
Pre-requisite(s):	CH3712, PH3002, admission to the M.Sci. year in the Materials Chemistry programme			
Anti-requisite(s):	PH4027			
Learning and teaching methods and delivery:	**Weekly contact**: fortnightly tutorials			
	Scheduled learning: 5 hours		**Guided independent study:** 95 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 100%, Practical Examinations = 0%, Coursework = 0%			
	As used by St Andrews: 1.5-hour Examination = 100%			
Module Co-ordinator:	Dr G A Turnbull			
Lecturer(s)/Tutor(s):	Dr G A Turnbull			

PH5101 Physics Project (M.Phys.)

SCOTCAT Credits:	60	SCQF Level 11	**Semester:**	Whole Year
Academic year:	2012/3			
Availability restrictions:	Normally available only to those in the final year of an M.Phys. Physics or M.Sci. Chemistry and Physics degree programme			
Planned timetable:	To be arranged.			

The project aims to develop students' skills in searching the physics literature and in experimental design, the evaluation and interpretation of data, and in the presentation of results. The main project is preceded by a review essay on a topic which is normally related to the theme of the project. There is no specific syllabus for this module. Students taking the M.Phys. 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. The review essay that precedes experimental work is worth 10 credits, ie should have about 100 hours of work invested in it. This work is expected to be directly useful to the subsequent experimental studies.

Programme module type:	Compulsory for Physics M.Phys. Either PH5101 or CH5441 is compulsory for Chemistry and Physics M.Sci.	
Pre-requisite(s):	PH3101	
Anti-requisite(s):	AS4103, AS5101, PH4111, PH5102	
Learning and teaching methods and delivery:	**Weekly contact**: Project students work "full-time" on their M.Phys. 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%	
Module Co-ordinator:	Dr D Cassettari	
Lecturer(s)/Tutor(s):	Dr D Cassettari	

PH5102 Project in Theoretical Physics

SCOTCAT Credits:	45	SCQF Level 11	**Semester:**	Whole Year
Academic year:	2012/3			
Availability restrictions:	Normally available only to those in the final year of a Theoretical Physics or Mathematics and Theoretical Physics degree programme.			
Planned timetable:	To be arranged.			

The project aims to survey the literature associated with the topic of the project and either (i) conduct original research into some problem in this field or (ii) prepare a research review of the field. In each case a written report is submitted in the range 5,000 to 10,000 words. There is no specific syllabus for this module. Students taking the M.Phys. Theoretical Physics 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 most of the 45 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, but students should note that this is "their" project and the outcome is primarily dependent on their input.

Programme module type:	Compulsory for Theoretical Physics Either PH5102 or MT5999 is compulsory for Theoretical Physics and Mathematics	
Anti-requisite(s):	AS4103, AS5101, PH4111, PH5101	
Learning and teaching methods and delivery:	**Weekly contact**: Project students should spend approximately three quarters of their time in semester 2 working on the project. All students must meet weekly with their project supervisor, and attend fortnightly meetings with their peer-support group. Most of their time will be spent working on theoretical physics in an independent fashion, though with the opportunity to discuss things with their supervisor face to face or electronically. In addition, all theoretical physics project students are encouraged to attend the fortnightly meeting theoretical physics research seminars.	
	Scheduled learning: 27 hours	**Guided independent study:** 423 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 0%, Practical Examinations = 0%, Coursework = 100%	
	As used by St Andrews: Coursework (project reports, presentation, and oral examination) = 100%	
Module Co-ordinator:	Dr C Hooley	
Lecturer(s)/Tutor(s):	Dr C Hooley	

PH5183 Photonics Applications

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Academic year:	2012/3			
Availability restrictions:	This module is intended for students in the final year of an M.Phys. or M.Sci. programme involving the School.			
Planned timetable:	To be arranged.			

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

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

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

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

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

Programme module type:	Optional for Astrophysics M.Phys., Physics and Mathematics B.Sc., Physics M.Phys., Physics and Chemistry M.Sci., Theoretical Physics M.Phys.	
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures and occasional tutorials.	
	Scheduled learning: 32 hours	**Guided independent study:** 118 hours
Assessment pattern:	**As defined by QAA:** Written Examinations = 80%, Practical Examinations = 0%, Coursework = 20%	
	As used by St Andrews: Coursework = 20%, 2-hour Written Examination = 80%	
Module Co-ordinator:	Prof T F Krauss	
Lecturer(s)/Tutor(s):	Prof T F Krauss, Prof K Dholakia, Dr A di Falco	

PH5208 Semiconductor Physics and Devices

SCOTCAT Credits:	10	SCQF Level 11	**Semester:**	1
Academic year:	2013/4			
Availability restrictions:	Distance Learning			
Planned timetable:	To be arranged.			
This is a distance-learning module covering the basic properties of semiconductor physics including their optical and electronic properties, and the low dimensional structures which may be constructed from them; and semiconductor devices ranging from pn junctions, solar cells, and LEDs to lasers, waveguides, optical amplifiers, optical modulators, and detectors.				
Programme module type:	Optional for Physics and Chemistry M.Sci.			
Learning and teaching methods and delivery:	**Weekly contact**: Material, tutorial support, and continuous assessment delivered at a distance by means of WebCT. Students are responsible for ensuring they have internet access. The course covers material equivalent to that covered in 30 conventional lectures.			
	Scheduled learning: 5 hours		**Guided independent study:** 95 hours	
Assessment pattern:	**As defined by QAA:** Written Examinations = 60%, Practical Examinations = 0%, Coursework = 40%			
	As used by St Andrews: Coursework = 40%, 2-hour Written Examination = 60%			
Module Co-ordinator:	Dr G A Turnbull			
Lecturer(s)/Tutor(s):	Dr G A Turnbull			