AS4010 Extragalactic Astronomy

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
Planned timetable:	To be arranged			

This module introduces the basic elements of extragalactic astronomy. This includes the morphological, structural and spectral properties of elliptical, spiral, quiescent and star-forming galaxies. We study how galaxy populations change from the distant galaxies in the early Universe into those observed in our local neighbourhood, including the coincident growth of super massive black holes at the centres of massive galaxies. Galaxy formation theory is introduced in relation to the growth of structure in a cold-dark matter Universe, and galaxy evolution in regions of high and low density is investigated. The module includes a look at modern instrumentation used in extragalactic astrophysics. Specialist lecturers from within the galaxy evolution research group will provide a direct link between material learnt in lectures and research currently being undertaken at the University of St Andrews. Students will engage in an assessed mini research project throughout the semester (computer based, in Python).

Pre-requisite(s):	Before taking this module you must (pass AS2001 or pass AS2101) and pass PH2011 and pass PH2012 and pass MT2501 and pass MT2503
Anti-requisite(s)	You cannot take this module if you take AS3011 or take AS4022
Learning and teaching methods of delivery:	**Weekly contact**: 1 or 2 x 1hr online lectures (A) x 10 weeks, 1hr tutorial (C) x 6 weeks, 1hr computational hack session x 4 weeks .
Assessment pattern:	2-hour Written Examination = 80%, continual assessment (Computer Based Assignment) = 20%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr R M Fernandes Tojeiro Reynolds
Module teaching staff:	Dr Rita Tojeiro; Prof Keith Horne; Dr Vivienne Wild

AS4011 The Physics of Nebulae and Stars 1

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
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.

Pre-requisite(s):	Before taking this module you must (pass AS2001 or pass AS2101) and pass PH2011 and pass PH2012 and (pass MT2001 or pass MT2501 and pass MT2503) and pass PH3081 or pass PH3082 or pass MT2003 or (pass MT2506 and pass MT2507)
Anti-requisite(s)	You cannot take this module if you take AS4023 or take AS3015
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures (A) x 10 weeks, 1hr tutorial (A,C) x 10 weeks
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr K Wood
Module teaching staff:	Dr Kenny Wood

AS4012 The Physics of Nebulae and Stars 2

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	2
Academic year:	2020-2021			
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.

Pre-requisite(s):	Before taking this module you must pass AS4011
Anti-requisite(s)	You cannot take this module if you take AS4023 or take AS3015
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures (A) x 11 weeks, 1hr problem-solving workshop (A/C) x 11 weeks
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr P Woitke
Module teaching staff:	Dr Peter Woitke; Prof Andrew Cameron

AS4015 Gravitational and Accretion Physics

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	2
Academic year:	2020-2021			
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 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.

Pre-requisite(s):	Before taking this module you must pass PH2011 and pass PH2012 and pass MT2501 and pass MT2503 and (pass PH3081 or pass PH3082 or pass MT2506 and pass MT2507)
Anti-requisite(s)	You cannot take this module if you take AS4021
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 online lectures (A) x 10 weeks, 1hr tutorial (A,C) x 6 weeks
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr H Zhao
Module teaching staff:	Dr Hongsheng Zhao

AS4025 Observational Astrophysics

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
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. The exact topics covered may change annually depending on resource availability; examples include galaxy imaging and exoplanet transits. Sources of data may include telescopes at the University Observatory and/or international observatories. Students gain experience in observation, data analysis, the Linux operating system, standard astronomical software packages and modelling, and report writing

Pre-requisite(s):	Before taking this module you must (pass AS2001 or pass AS2101) and pass PH2011 and pass PH2012 and (pass MT2001 or pass 2 modules from {MT2501, MT2503})
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 3.5hr x 10 weeks supervised online work
Assessment pattern:	Coursework = 100%
Re-assessment pattern:	No Re-assessment available - laboratory based
Module coordinator:	Professor A C Cameron
Module teaching staff:	Prof Andrew Cameron; Dr Alexander Scholz

AS5001 Advanced Data Analysis

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	This module is intended for students in the final year of an MPhys or MSci programme involving the School, and for those taking the MSc in Astrophysics.			
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.

Pre-requisite(s):	Familiarity with scientific programming language essential, for example through AS3013 or PH3080. Entry to an MPhys programme in the school or MSc Astrophysics.
Learning and teaching methods of delivery:	**Weekly contact**: 3 x 1hr online lectures (A) x 5 weeks, 2 x 1hr office hours (A) x 5 weeks, 1hr in-person workshop (C) x 5 weeks .
Assessment pattern:	Coursework = 100%
Re-assessment pattern:	No Re-assessment available - laboratory based
Module coordinator:	Professor K D Horne
Module teaching staff:	Prof Keithe Horne; Prof Andrew Cameron

AS5002 Magnetofluids and Space Plasmas

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	This module is intended for students in the final year of an MPhys or MSci programme involving the School, and for those on the Astrophysics MSc			
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.

Pre-requisite(s):	Before taking this module you must pass 1 module from {PH3007, MT4510, MT4553} and pass 1 module from {AS3013, PH4030, PH3080, MT3802, MT4112}
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures (A) x 10 weeks, 1hr tutorial (A) x 10 weeks
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Professor M M Jardine
Module teaching staff:	Prof Moira Jardine

AS5003 Contemporary Astrophysics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Available only to MPhys Astrophysics or MSc Astrophysics students.			
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.

Pre-requisite(s):	For MPhys: before taking this module you must pass AS4010, AS4012, PH3061 and PH3081. For MSc: students must have substantial astronomy knowledge and skills.
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures (A) x 10 weeks, 1hr tutorial (B) x 5 weeks, 1hr online tutorial (A) x 5 weeks
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr H Zhao
Module teaching staff:	Dr Hongsheng Zhao; Dr Christiane Helling

AS5500 Research Skills in Astrophysics

SCOTCAT Credits:	30	SCQF Level 11	**Semester**	Full Year
Academic year:	2020-2021			
Availability restrictions:	Available only to students on MSc Astrophysics.			
Planned timetable:	To be arranged			
This module will provide the basic astrophysical background and will introduce students to the research skills needed for a career in astrophysics. The module consists of a series of introductory lectures and practicals on basic astrophysical concepts, followed by a tutorial-based system to introduce the skills of astrophysical research. These skills include the critical analysis of the scientific literature; presenting research topics and results to a scientific and general audience; a basic computational competence; and undertaking novel research in areas of current astrophysical interest, potentially including science education and public outreach. In Semester 1 students will attend weekly AS5500 meetings and work on research skills assignments. Students work 'half-time' on their project through semester 2. All students must meet weekly with their project supervisor and attend the weekly AS5500 meetings. Most projects are based in research groups 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.				
Pre-requisite(s):	Students must be registered on MSc Astrophysics.			
Learning and teaching methods of delivery:	**Weekly contact**: S1: 1hr in-person or online tutorial (A/C) x 10 weeks, 3hr onilne presentation session (A) x 1 week, 1hr research seminars (A) x 10 weeks. S2: 1hr in-person or online tutorial (A/C) x 10 weeks, 3hr online presentation session (A) x 1 week, 1hr research seminars (A) x 10 weeks, 1hr online or in-person supervisor meetings (A/C) x 11 weeks			
Assessment pattern:	Coursework = 100%			
Module coordinator:	Dr A Weijmans			
Module teaching staff:	Dr Anne-Marie Weijmans; Prof Moira Jardine			

AS5521 Observational Techniques in Astrophysics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	Full Year
Academic year:	2020-2021			
Availability restrictions:	Available only to students on MSc Astrophysics.			
Planned timetable:	To be arranged			
This is a module that provides a complete overview of the practical part of research in observational astronomy. In the laboratory part, students learn how to plan observations with telescopes at the university observatory, followed by data reduction and analysis. The exact topics covered may change annually depending on resource availability; examples include galaxy imaging and exoplanet transits. The lecture part prepares the students for working with large-scale professional facilities and advanced observing techniques. The module includes optional observing training either with the James Gregory Telescopes in St Andrews, or with telescopes overseas. This training can be hands-on or remotely. Overall, students gain valuable experience in observation, data analysis, astronomical software, observing techniques, report and proposal writing.				
Pre-requisite(s):	Students must be registered for MSc Astrophysics.			
Co-requisite(s):	You must also take AS5500			
Learning and teaching methods of delivery:	**Weekly contact**: Semester 1: 2 x 3.5hr supervised online work (A) x 10 weeks. Semester 2: 1hr interactive lecture (C) x10 weeks			
Assessment pattern:	Coursework = 100%			
Module coordinator:	Dr A Scholz			
Module teaching staff:	Dr Alexander Scholz; Dr Anne-Marie Weijmans			

AS5522 Stellar Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on MSc Astrophysics.			
Planned timetable:	To be arranged			

This module develops the physics of stellar interiors and atmospheres from the basic equations of stellar structure and 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.

Pre-requisite(s):	Students must be registered for MSc Astrophysics.. Before taking this module you must pass AS4011 or equivalent from first degree.
Co-requisite(s):	You must also take AS5500
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures x 11 weeks, 1hr online/in-person workshop x 11 weeks
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Module coordinator:	Dr P Woitke
Module teaching staff:	Dr Peter Woitke; Prof Andrew Cameron

AS5523 Gravitational Dynamics and Accretion Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on MSc Astrophysics.			
Planned timetable:	To be arranged			

This theoretical module explores the basics of gravitational dynamics and accretion physics and their application to systems such as circumstellar discs, stellar clusters to galaxies and clusters of galaxies. The module will provide students with the techniques to determine physical properties from observable quantities and to model the dynamics and evolutionary pathways of these systems. 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. Accretion as a source of energy and mass growth will be explored with particular emphasis on models of viscous accretion discs. Applications of these methods are made to several different astrophysical objects including accretion discs in stellar systems, collisions in globular clusters, the growth of super-massive black holes, to the presence of dark matter in the universe.

Pre-requisite(s):	Students must be registered for MSc Astrophysics.
Co-requisite(s):	You must also take AS5500
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 online lectures (A) x 10 weeks, 1hr tutorial (A,C) x 6 weeks
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Module coordinator:	Dr H Zhao
Module teaching staff:	Dr Hongsheng Zhao

AS5524 Astrophysical Fluid Dynamics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on MSc Astrophysics.			
Planned timetable:	To be arranged			

Fluid dynamics is the study of all things that 'flow', whether they are liquids or gases. The underlying concepts and techniques taught in this course are of wide ranging use, finding application in such diverse problems as the collision of galaxies, spacecraft re-entry into the Earth's atmosphere, or the structure and stability of fusion plasmas. Closer to home, the behaviour of fluid flows can readily be observed in rivers, on shorelines and in cloud formations. Fluid mechanics describes the types of flows that result from different forces (such as gravity). It explains how (and why) flows become supersonic and when they may become unstable. These basic principles can then be applied to a variety of problems. In addition to introducing the concepts of fluid dynamics, and describing their application, this course will provide the students with the opportunity to develop the numerical skills required for a computational approach to the problem. This project will account for 20% of the module grade, with the remaining 80% coming from the exam.

Pre-requisite(s):	Registration on MSc Astrophysics.
Co-requisite(s):	You must also take AS5500
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures x10 weeks, 1hr workshop x 3 weeks, 1hr tutorial x 5 weeks
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Module coordinator:	Dr C Helling
Module teaching staff:	Dr Christiane Helling

AS5599 Astrophysics Research Project (MSc)

SCOTCAT Credits:	60	SCQF Level 11	**Semester**	Full Year
Academic year:	2020-2021			
Availability restrictions:	Available only to students on MSc Astrophysics.			
Planned timetable:	To be arranged			

The project aims to develop students' skills in searching the appropriate literature, in astrophysical theory or experimental and observational design, the evaluation and interpretation of data, and the presentation of a report. There is no specific syllabus for this module. Students taking the MSc Astrophysics degree select a project from a list of those available and are supervised by a member of the academic staff.

Pre-requisite(s):	Registration on MSc Astrophysics. Some projects will need learning from specific modules - please contact potential supervisors.
Co-requisite(s):	You must also take AS5500
Learning and teaching methods of delivery:	**Weekly contact**: 1hr online peer group session (A) x 11 weeks, 1hr online supervisory meeting (C) x 11 weeks, 1hr online research seminar (A) x 12 weeks .
Assessment pattern:	Coursework = 100%
Module coordinator:	Professor M M Jardine
Module teaching staff:	School staff

ID5220 Biomedical Imaging and Sensing

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Only available to students on the MSc Digital Health			
Planned timetable:	To be confirmed			
Medical imaging and sensing technology plays a major role in the way people are diagnosed and treated in hospitals. Exploring these technologies and the data analysis behind them enhances their current use and allows for insight into their potential future development. This module will cover: the different types of medical imaging (such as MRI, CT, PET, ultrasound and optical imaging), the fundamental principles of these techniques, their uses and limitations in a clinical setting. We further study applicable data treatment and signal processing techniques, including how to program these.				
Pre-requisite(s):	Before taking this module you must pass MT5762			
Learning and teaching methods of delivery:	**Weekly contact**: 2 sessions per week of 2.5 hours each which include lectures and guided practical classes (X11 weeks)			
Assessment pattern:	2-hour Written Examination = 60%, Coursework = 40%			
Re-assessment pattern:	Oral Examination with results capped at grade 7 = 100%			
Module coordinator:	Dr M Mazilu			
Module teaching staff:	Dr M Mazilu, Dr A Gillies, Dr P Cruickshank (TBC)			

PH4026 Signals and Information

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	2
Academic year:	2020-2021			
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.				
Pre-requisite(s):	Before taking this module you must pass PH3081 or pass PH3082 or (pass MT2506 and pass MT2507)			
Learning and teaching methods of delivery:	**Weekly contact**: 2 x online lectures (A) x 11 weeks, 1hr in-person workshop (C) x 5 weeks, 1hr online Q and A (A) x 5 weeks			
Assessment pattern:	2-hour Written Examination = 100%			
Re-assessment pattern:	Oral Re-assessment, capped at grade 7			
Module coordinator:	Dr P A S Cruickshank			
Module teaching staff:	Dr Paul Cruickshank; Dr Graham Smith			

PH4027 Optoelectronics and Nonlinear Optics

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
Planned timetable:	To be arranged			

This module provides an introduction to the basic physics underpinning optoelectronics and nonlinear optics, and its applications including displays and communications. The syllabus consists of: an overview of optoelectronic devices and systems; displays - types of display, liquid crystal displays, organic semiconductors and organic light-emitting diode (OLED) displays; nonlinear optics - propagation of light in anisotropic media, coupled wave equations; second harmonic generation; phase matching; and electro-optic modulators; fibres and telecommunications including modes of planar waveguides, factors limiting data transmission rates and detectors.

Pre-requisite(s):	Before taking this module you must (pass PH3081 or pass PH3082) or (pass MT2506 and pass MT2507) and pass PH3007
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures (A) x 10 weeks, 1hr in-person workshop (C) x 10 weeks
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Professor I D W Samuel
Module teaching staff:	Prof Ifor Samuel; Dr Sebastian Schulz

PH4028 Advanced Quantum Mechanics: Concepts and Methods

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	2
Academic year:	2020-2021			
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. The mathematics of complex analysis is introduced to allow this to be used for relevant quantum mechanics problems. Scattering theory is developed using partial waves and Green's functions, leading to a discussion of quantum degenerate gases. Advanced topics in perturbation theory including WKB approximation for exploring differential equations. The density matrix formalism as the general state description in open quantum systems is presented; open system dynamics are described within the formalism of the density matrix master equation. Quantum information processing is covered, including concepts such as qubits, quantum entanglement and quantum teleportation.

Pre-requisite(s):	Before taking this module you must pass PH3061 and pass PH3062 and (pass PH3081 or pass PH3082) or (pass MT2003 or pass MT2506 and pass MT2507)
Learning and teaching methods of delivery:	**Weekly contact**: Weekly contact: 2 x 1hr online lectures (A) x 10 weeks, 1hr online discussion sessions (A) x 5 weeks, 1hr in-person tutorial (C) x 6 weeks
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr B W Lovett
Module teaching staff:	Dr Brendon Lovett

PH4031 Fluids

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	2
Academic year:	2020-2021			
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.

Pre-requisite(s):	Before taking this module you must pass PH3081 or pass PH3082 or (pass MT2506 and pass MT2507)
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures (A) x10 weeks, 1hr in-person workshop (C) x 3 weeks, 1hr in-person tutorial (C) x 5 weeks
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr C Helling
Module teaching staff:	Dr Christiane Helling

PH4032 Special Relativity and Fields

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
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.

Pre-requisite(s):	Before taking this module you must pass PH3007 and pass PH3081 and pass PH4038
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures x 10 weeks, 1hr tutorial x 10 weeks
Assessment pattern:	2-hour Written Examination = 75%, Coursework (assessed tutorial questions) = 25%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Professor N Korolkova
Module teaching staff:	Prof Natalia Korolkova

PH4034 Principles of Lasers

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	2
Academic year:	2020-2021			
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.				
Pre-requisite(s):	Before taking this module you must pass PH3081 or pass PH3082 or (pass MT2506 and pass MT2507)			
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures x 11 weeks, 1hr in-person tutorial (C) x 11 weeks			
Assessment pattern:	2-hour Written Examination = 90%, Coursework = 10%			
Re-assessment pattern:	Oral Re-assessment, capped at grade 7			
Module coordinator:	Dr F E W Koenig			
Module teaching staff:	Dr Friedrich Koenig			

PH4035 Principles of Optics

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
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.				
Pre-requisite(s):	Before taking this module you must pass PH3081 or pass PH3082 or (pass MT2506 and pass MT2507)			
Learning and teaching methods of delivery:	**Weekly contact**: 3 x 1hr online lectures (A) x 10 weeks, 1hr mixed online/in-person workshop (C,A) x 5 weeks, 1hr in-person workshop (C) x 5 weeks			
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%			
Re-assessment pattern:	Oral Re-assessment, capped at grade 7			
Module coordinator:	Dr F E W Koenig			
Module teaching staff:	Dr Friedrich Koenig			

PH4036 Physics of Music

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
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. The module includes a look at how digital audio of musical instrument sounds can be analysed and synthesised using a programming language such a Python.

Pre-requisite(s):	Before taking this module you must pass PH3081 or pass PH3082
Learning and teaching methods of delivery:	**Weekly contact**: 2hr x 10 weeks online lectures, 1hr x 10 weeks tutorial (C)
Assessment pattern:	Written examinations :80%. Continual assessment: 20%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr J A Kemp
Module teaching staff:	Dr Jonathan Kemp

PH4038 Lagrangian and Hamiltonian Dynamics

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	2
Academic year:	2020-2021			
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 the central force problem (orbits and scattering) and coupled oscillators.

Pre-requisite(s):	In taking this module you will need a knowledge of vector calculus. Before taking this module you must pass PH3081 or pass PH3082 or (pass MT2506 and pass MT2507)
Anti-requisite(s)	You cannot take this module if you take MT4507
Learning and teaching methods of delivery:	**Weekly contact**: 3 x 1hr online lectures (A) x 11 weeks, 1hr in-person workshop (C) x 11 weeks
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr B H Braunecker
Module teaching staff:	Dr Bernd Braunecker
Additional information from Schools:	

PH4039 Introduction to Condensed Matter Physics

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
Planned timetable:	To be arranged			

This module explores how the various thermal and electrical properties of solids are related to the nature and arrangement of their constituent atoms. For simplicity, emphasis is given to crystalline solids. The module covers: the quantum-mechanical description of electron motion in crystals; the origin of band gaps and insulating behaviour; the reciprocal lattice and the Brillouin zone, and their relationships to X-ray scattering measurements; the band structures and Fermi surfaces of simple tight-binding models; the Einstein and Debye models of phonons, and their thermodynamic properties; low-temperature transport properties of insulators and metals, including the Drude model; the physics of semiconductors, including doping and gating; the effect of electron-electron interactions, including a qualitative account of Mott insulators; examples of the fundamental theory applied to typical solids.

Pre-requisite(s):	Before taking this module you must pass PH3081 or pass PH3082 or (pass MT2506 and pass MT2507) and (pass PH3061 or pass CH3712)
Co-requisite(s):	You must also take PH3061 or take PH3082 or take PH3081
Learning and teaching methods of delivery:	**Weekly contact**: 3 x 1hr online lectures (A) x10 weeks, 1hr in-person workshop (C) x 5 weeks, 1hr in-person tutorial x 5 weeks
Assessment pattern:	2-hour Written Examination = 80%, Coursework = 20%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr C A Hooley
Module teaching staff:	Dr Chris Hooley
Additional information from Schools:	To be confirmed

PH4105 Physics Laboratory 2

SCOTCAT Credits:	15	SCQF Level 10	**Semester**	1
Academic year:	2020-2021			
Planned timetable:	To be arranged			

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 low temperature solid state physics, optics, x-ray crystallography, and biophotonics.

Pre-requisite(s):	Before taking this module you must pass PH3081 or pass PH3082 or (pass MT2506 and pass MT2507)
Learning and teaching methods of delivery:	**Weekly contact**: 2 x 3.5hr in person laboratory (D) x 10 weeks
Assessment pattern:	100% continual assessment.
Re-assessment pattern:	No Re-assessment available - laboratory based
Module coordinator:	Dr C F Rae
Module teaching staff:	Dr Cameron Rae and School staff

PH5004 Quantum Field Theory

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci 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, solving simple models using second quantization, 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, solving many-body quantum problems with mean-field theory, and applications of field theoretic methods to models of magnetism.

Pre-requisite(s):	Before taking this module you must pass PH3012 and pass PH3061 and pass PH3062 and pass 1 module from {PH4038, MT4507} and pass 1 module from {PH4028, MT3503}
Learning and teaching methods of delivery:	**Weekly contact**: 2.5 x 1hr online lectures (A) x 10 weeks . 1 x 10 weeks tutorials and discussion sessions
Assessment pattern:	2-hour Written Examination = 85%, Coursework = 15%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr J M J Keeling
Module teaching staff:	Dr Jonathan Keeling

PH5005 Laser Physics and Design

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School			
Planned timetable:	To be arranged			

Quantitative treatment of laser physics including rate equations; transient/dynamic behaviour of laser oscillators including relaxation oscillations, Q-switching, cavity dumping and mode locking; single-frequency selection and frequency scanning, design analysis of optically-pumped solid state lasers; laser amplifiers; unstable optical resonators, geometric and diffraction treatments. An emphasis is placed on how understanding of the laser physics can be used to design useful laser systems.

Pre-requisite(s):	Before taking this module you must pass PH3007 and pass PH3061 and pass PH3062
Anti-requisite(s)	You cannot take this module if you take PH5180 and take PH4034
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 x 1hr online lectures (A) x 10 weeks, 1hr in-person tutorial (C) x 4 weeks
Assessment pattern:	2.5-hour open-notes Written Examination = 80%, Coursework = 20%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr B D Sinclair
Module teaching staff:	Dr Bruce Sinclair; Dr Hamid Ohadi; Dr Liam O'Faolain

PH5011 General Relativity

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School, or as part of MSc Astrophysics.			
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.

Pre-requisite(s):	Postgraduates: MSc Astrophysics students must discuss your prior learning with your adviser.. Before taking this module you must pass PH3081 or pass PH3082 or (pass MT2506 and pass MT2507)
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 online lectures or tutorials (A)
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr M Dominik
Module teaching staff:	Dr Martin Dominik
Additional information from Schools:	To be confirmed

PH5012 Quantum Optics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci 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.

Pre-requisite(s):	Before taking this module you must (pass PH3081 or pass PH3082 or pass MT2506 and pass MT2507) and pass PH3061 and pass PH3062 and pass PH4028
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 1hr online lectures (A) x 10 weeks , 1hr in-person tutorial (C) x 6 weeks, 1hr online tutorial (A) x 4 weeks
Assessment pattern:	2-hour Written Examination = 100%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Professor N Korolkova
Module teaching staff:	Prof Natalia Korolkova; Dr Friedrich Koenig

PH5015 Applications of Quantum Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School, or a postgraduate photonics programme.			
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.

Learning and teaching methods of delivery:	**Weekly contact**: 2 x 1hr online lectures (A) x 10 weeks, 1hr in-person tutorial/discussion session (C) x 10 weeks, 3 hours student presentations
Assessment pattern:	2-hour Written Examination = 80%, Coursework = 20%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr D Cassettari
Module teaching staff:	Dr Donatella Cassettari

PH5016 Biophotonics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School, or a postgraduate photonics programme.			
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, optogenetics, 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.

Pre-requisite(s):	Pre-requisites are compulsory unless you are on a taught postgraduate programme.. Before taking this module you must (pass 1 module from {PH3081, PH3082} or pass 2 modules from {MT2506, MT2507}) and pass 1 module from {PH4034, PH4035}
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 x1hr online lectures (A) x 10 weeks, 1hr online or in-person tutorial (A/C) x 10 weeks
Assessment pattern:	2-hour Written Examination = 80%, Coursework (including presentation)= 20%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Dr J C Penedo-Esteiro
Module teaching staff:	Dr Carlos Penedo; Prof Kishan Dholakia; Dr Marcel Schubert; Prof Frank Gunn-Moore

PH5023 Monte Carlo Radiation Transport Techniques

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Normally only taken in the final year of an MPhys or MSci programme involving the School, or as part of MSc Astrophysics.			
Planned timetable:	To be arranged			

This module introduces the theory and practice behind Monte Carlo radiation transport codes for use in physics, astrophysics, atmospheric physics, and medical physics. Included in the module: recap of basic radiation transfer; techniques for sampling from probability distribution functions; a simple isotropic scattering code; computing the radiation field, pressure, temperature, and ionisation structure; programming skills required to write Monte Carlo codes; code speed-up techniques and parallel computing; three-dimensional codes. The module assessment will be 100% continuous assessment comprising homework questions and small projects where students will write their own and modify existing Monte Carlo codes.

Pre-requisite(s):	Undergraduates: Before taking this module you must pass PH2012 and pass at least 1 module from {AS3013, PH3080, PH3081, PH3082}.. Postgraduates: MSc Astrophysics students must discuss their prior learning with their adviser
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 x 1hr online lectures (A) x 5 weeks, 1hr x in-person tutorial (C) x 5 weeks, 2hr in-person computer session (C) x 3 weeks.
Assessment pattern:	Coursework (worksheets = 50%, 3-hour computing test = 25%, 1-hour Class Test = 25%) = 100%
Re-assessment pattern:	No Re-assessment available - laboratory based
Module coordinator:	Dr K Wood
Module teaching staff:	Dr Kenny Wood

PH5025 Nanophotonics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	Available only to students in a photonics taught postgraduate programme or the final year of an MPhys Honours Programme			
Planned timetable:	To be arranged			

Nanophotonics deals with structured materials on the nanoscale for the manipulation of light. Photonic crystals and plasmonic metamaterials are hot topics in contemporary photonics, and form part of the School's research programme. The properties of these materials can be designed to a significant extent via their structure. Many of the properties of these nanostructured materials can be understood from their dispersion diagram or optical band-structure, which is a core tool that will be explored in the module. Familiar concepts such as optical waveguides and cavities, multilayer mirrors and interference effects will be used to explain more complex features such as slow light propagation and high Q cavities in photonic crystal waveguides and supercontinuum generation in photonic crystal fibres. Propagating and localized plasmons will be explained and will include the novel effects of super-lensing and advanced phase control in metamaterials.

Pre-requisite(s):	Undergraduates: before taking this module you must take PH3061 and (take PH3081 or take PH3082) and (take PH4027 or take PH4034 or take PH4035). Postgraduates: students should be familiar with Maxwell's Equations of Electromagnetism in differential form.
Anti-requisite(s)	You cannot take this module if you take PH5183
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 1hr online lectures x 10 weeks, 1hr online/in-person tutorial (A,C) x 6 weeks
Assessment pattern:	2-hour Written Examination = 80%, Coursework = 20%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7
Module coordinator:	Professor A Di Falco
Module teaching staff:	Prof Andrea Di Falco

PH5026 Supported Study Module

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	This module is only available by special permission of the Head of School. It is being provided to help with MPhys students in two different situations:- 1) Those who are on a reduced credit load and so may need to take 15 credits at level 5 in their penultimate year 2) Those who are unexpectedly in need of another 15 credits to be taken with their MPhys project in their final semester.			
Planned timetable:	To be arranged			
On rare occasions a student may need a level 5 module in semester two for their Physics or Astronomy MPhys degree programme, and this module may fulfil that need. This module is available only by special permission from the Head of School of Physics and Astronomy, and is expected to be taken rarely. This module is available only to students studying on an MPhys degree in Physics, Astrophysics, or Theoretical Physics. The topic and intended learning outcomes of this supported study module will be the same as that of one of the existing semester-one undergraduate level-five AS or PH modules that the School is in a position to offer at the time. Reading will be set weekly to cover the necessary content, and in many weeks tutorial sheets will be issued to be completed. This will be discussed in a weekly tutorial. There are no lectures.				
Pre-requisite(s):	Before taking this module you must pass PH3061			
Learning and teaching methods of delivery:	**Weekly contact**: 1 hour tutorial (11 weeks)			
Assessment pattern:	2-hour Written Examination = 100%			
Re-assessment pattern:	Oral Re-assessment, capped at grade 7			
Module teaching staff:	To be arranged			

PH5177 Research Project (POED MSc)

SCOTCAT Credits:	60	SCQF Level 11	**Semester**	Full Year
Academic year:	2020-2021			
Availability restrictions:	This project module is organised and assessed with Heriot Watt as the lead institution in 2017/8 and alternate years thereafter, St Andrews in 2018/9 and alternate years after that. It is available only to those in the Photonics and Optoelectronic Devices MSc programme.			
Planned timetable:	To be arranged			
All POED MSc students carry out a 3-month research project, in most cases carried out at a U.K. company. Part-time students who are industry employees may carry out the project at their own company. Students may have completed a literature survey prior to the project, and will write a dissertation on the project which is assessed in September.				
Learning and teaching methods of delivery:	**Weekly contact**: 40 hours a week working on the project, with appropriate levels of supervision			
Assessment pattern:	Dissertation and Oral Examination = 100%			
Re-assessment pattern:	No Re-Assessment possible, project module			
Module coordinator:	Professor A Di Falco			
Module teaching staff:	To be arranged			

PH5181 Photonics Laboratory 1

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Planned timetable:	To be arranged			
The photonics teaching laboratory gives training in the experimental photonics, and allows students the opportunity to explore photonics practically in a series of chosen open-ended investigations. Students use their knowledge and skills from the lecture modules, supplemented by additional reading, to investigate relevant photonic effects. Phase I involves work in small groups in introductory areas, then phase II allows primarily individual investigation of topics such as the second harmonic generation, optical parametric oscillation, erbium amplifiers, Nd lasers, optical tweezers, spectroscopy, remote sensing of speed, Brag reflectors, and holography.				
Pre-requisite(s):	Admission pre-requisite			
Learning and teaching methods of delivery:	**Weekly contact**: 3 x 3.5 hr in-person lab or direct lab prep			
Assessment pattern:	Coursework = 100%			
Re-assessment pattern:	No Re-Assessment available, lab-based module			
Module coordinator:	Dr B D Sinclair			
Module teaching staff:	Dr Bruce Sinclair; Dr Friedrich Koenig; Prof Andrea Di Falco; Prof Graham Turnbull; Dr Hamid Ohadi			

PH5184 Photonics Experimental Laboratory 2 (B21HL)

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on the Photonics and Optoelectronic Devices MSc programme			
Planned timetable:	To be arranged			
This module is taught at Heriot-Watt University, and forms part of certain taught Master's degrees run collaboratively between St Andrews and Heriot-Watt Universities.				
Learning and teaching methods of delivery:	**Weekly contact**: At Heriot-Watt University			
Assessment pattern:	Coursework = 100%			
Re-assessment pattern:	If any, will be under Heriot-Watt regulations			
Module teaching staff:	To be arranged			

PH5185 Semiconductor Optoelectronic Devices (B21OD)

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on the Photonics and Optoelectronic Devices MSc programme			
Planned timetable:	To be arranged			
This module is taught at Heriot-Watt University, and may form part of certain taught Master's degrees run collaboratively between St Andrews and Heriot-Watt Universities.				
Learning and teaching methods of delivery:	**Weekly contact**: At Heriot-Watt University			
Assessment pattern:	3-hour Written Examination = 100%			
Re-assessment pattern:	Under Heriot-Watt regulations			
Module teaching staff:	To be arranged			

PH5187 Fibres and Nonlinear Optics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on the Photonics and Optioelectronic Devices MSc programme			
Planned timetable:	To be arranged			
This module is taught at Heriot-Watt University, and may form part of certain taught Master's degrees run collaboratively between St Andrews and Heriot-Watt Universities.				
Learning and teaching methods of delivery:	**Weekly contact**: At Heriot-Watt University			
Assessment pattern:	3-hour Written Examination = 100%			
Re-assessment pattern:	Under Heriot-Watt regulations			
Module teaching staff:	To be arranged			

PH5188 Image Processing (B31SE)

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on the Photonics and Optioelectronic Devices MSc programme			
Planned timetable:	To be arranged			
This module is taught at Heriot-Watt University, and may form part of certain taught Master's degrees run collaboratively between St Andrews and Heriot-Watt Universities.				
Learning and teaching methods of delivery:	**Weekly contact**:			
Assessment pattern:				
Module teaching staff:	To be arranged			

PH5189 Photonics Sensors

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on the Photonics and Optoelectronic Devices MSc programme			
Planned timetable:	To be arranged			
This module is taught at Heriot-Watt University, and may form part of certain taught Master's degrees run collaboratively between St Andrews and Heriot-Watt Universities.				
Learning and teaching methods of delivery:	**Weekly contact**: At Heriot-Watt University			
Assessment pattern:	Written Examination = 80%, Coursework = 20%			
Re-assessment pattern:	Under Heriot-Watt regulations			
Module teaching staff:	To be arranged			

PH5190 Soft Matter and Biophysics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on the Photonics and Optoelectronic Devices MSc programme			
Planned timetable:	To be arranged			
This module is taught at Heriot-Watt University, and may form part of certain taught Master's degrees run collaboratively between St Andrews and Heriot-Watt Universities.				
Learning and teaching methods of delivery:	**Weekly contact**: At Heriot-Watt University			
Assessment pattern:	Written Examination = 80%, Coursework = 20%			
Re-assessment pattern:	Under Heriot-Watt regulations			
Module teaching staff:	To be arranged			

PH5191 Nanophysics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	2
Academic year:	2020-2021			
Availability restrictions:	Available only to students on the Photonics and Optoelectronic Devices MSc programme			
Planned timetable:	To be arranged			
This module is taught at Heriot-Watt University, and may form part of certain taught Master's degrees run collaboratively between St Andrews and Heriot-Watt Universities.				
Learning and teaching methods of delivery:	**Weekly contact**: At Heriot-Watt University			
Assessment pattern:	Written Examination = 100%			
Re-assessment pattern:	Under Heriot-Watt regulations			
Module teaching staff:	To be arranged			

PH5192 Optical Imaging Concepts

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	This module is limited to students registered on the EngD in Applied Photonics and the MSc in Photonics and Optoelectronic Devices.			
Planned timetable:	To be arranged			
This module aims to introduce the theory and applications of key imaging concepts that are in widespread use. The content includes on the underpinning side:- plane waves form Maxwell's equations, refractive index, polarisation, coherence, diffraction, Fourier optics, lenses and aberrations, optical instruments, point spread function. On the more system side the content includes material drawn from some of:-adaptive optics, multi-modal microscopies, super-resolution, optical coherence tomography, ghost and hyperspectral imaging and other contemporary imaging scenarios.				
Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 x 1hr online lectures (A) x 10 weeks, 1hr in-person or online workshop (A/C) x 5 weeks, 1hr in-person tutorial x 5 weeks			
Assessment pattern:	Written Examination = 80%, Coursework = 20%			
Re-assessment pattern:	Practical (Oral) Examination = 100%			
Module coordinator:	Dr F E W Koenig			
Module teaching staff:	Dr Friedrich Koenig; Dr Sebastian Schulz			

PH5193 Laser Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester**	1
Academic year:	2020-2021			
Availability restrictions:	This module is available only for those in the Engineering Doctorate in Applied Photonics and the MSc in Photonics and Optoelectronic Devices.			
Planned timetable:	To be arranged			

This module presents a description of the main physical concepts upon which an understanding of laser materials, operations, and applications can be based. These concepts include a treatment of light-matter interaction, absorption and refractive index, rate-equation theory of lasers, gain and its saturation, frequency selection and tuning in lasers, transient phenomena, resonator and beam optics, and the principles and techniques of ultrashort pulse generation and measurement.

Learning and teaching methods of delivery:	**Weekly contact**: 2 or 3 x 1hr online lectures (A) x 10 weeks, 1hr in-person or online workshop (A/C) x 5 weeks, 1hr in-person tutorial x 5 weeks
Assessment pattern:	2.5-hour Written Examination = 80%, Coursework = 20%
Re-assessment pattern:	Oral Re-assessment, capped at grade 7 = 100%
Module coordinator:	Dr B D Sinclair
Module teaching staff:	Dr Bruce Sinclair; Dr Hamid Ohadi; Dr Liam O'Faolain