Master of Science Astrophysics

Programme Requirements

Astrophysics - MSc
AS5500 (30 credits) **and** 90 credits from Module List: AS4010 - AS4011, AS5001 - AS5003, AS5521 - AS5524, PH5011, PH5023 **and** AS5599 (60 credits)

Compulsory modules:

AS5500 Research Skills in Astrophysics				
SCOTCAT Credits:	30	SCQF Level 11	**Semester:**	Whole Year
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.				
Programme module type:	Compulsory for MSc in Astrophysics			
Learning and teaching methods and delivery:	**Weekly contact**: 15 hours of lectures, 20 hours of seminars and 20 hours of tutorials			
Assessment pattern:	Coursework = 100%			
Module coordinator:	Dr A Weijmans			
Module teaching staff:	Dr A Weijmans, Prof M Jardine, with others			

AS5599 Astrophysics Research Project (MSc)				
SCOTCAT Credits:	60	SCQF Level 11	**Semester:**	Summer
Planned timetable:	Available only to students on the MSc in Astrophysics.			
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.				
Programme module type:	Compulsory for MSc in Astrophysics			
Pre-requisite(s):	BSc or equivalent in the physical sciences			
Co-requisite(s):	AS5500			
Learning and teaching methods and delivery:	**Weekly contact**: 1-hour peer group sessions (x 12), 2-hour supervisions (x 12)			
Assessment pattern:	Coursework = 100%			
Module coordinator:	Prof I Bonnell			
Module teaching staff:	Prof I Bonnell with others			

Optional modules:

AS4010 Extragalactic Astronomy				
SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Planned timetable:	12.00 noon Mon, Tue, Thu (TBC)			
This module introduces the basic elements of extragalactic astronomy. This includes the morphological, structural and spectral properties of elliptical, spiral, quiescent and star-forming galaxies. We study how galaxy populations change from the distant galaxies in the early Universe into those observed in our local neighbourhood, including the coincident growth of super massive black holes at the centres of massive galaxies. Galaxy formation theory is introduced in relation to the growth of structure in a cold-dark matter 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.				
Programme module type:	Optional for MSc in Physics			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures occasionally replaced by tutorials			
Assessment pattern:	2-hour Written Examination = 80%, Coursework = 20%			
Module coordinator:	Dr V Wild (TBC)			
Module teaching staff:	Dr V Wild, Dr A M Weijmans (TBC)			

AS4011 The Physics of Nebulae and Stars 1				
SCOTCAT Credits:	15	SCQF Level 10	**Semester:**	1
Planned timetable:	10.00 am Tue, Wed, Thu (TBC)			
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:	Optional for MSc in Astrophysics, Optional for MSc in Physics			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures occasionally replaced by whole-group tutorials.			
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%			
Module coordinator:	Dr K Wood (TBC)			
Module teaching staff:	Dr K Wood (TBC)			

AS5001 Advanced Data Analysis

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Planned timetable:	9.00 am Tue, Thu, 10.00 am Mon, 12.00 noon Thu and 3.00 pm - 5.00 pm Tue (Lab) (TBC)			
This module develops an understanding of basic concepts and offers practical experience with the techniques of quantitative data analysis. Beginning with fundamental concepts of probability theory and random variables, practical techniques are developed for using quantitative observational data to answer questions and test hypotheses about models of the physical world. The methods are illustrated by applications to the analysis of time series, imaging, spectroscopy, and tomography datasets. Students develop their computer programming skills, acquire a data analysis toolkit, and gain practical experience by analyzing real datasets.				
Programme module type:	Optional for Postgraduate programmes in the School.			
Pre-requisite(s):	Admission to a taught Postgraduate degree programme in the School.			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials and some supervised computer lab sessions			
Assessment pattern:	Coursework = 100%			
Module coordinator:	Prof K Horne (TBC)			
Module teaching staff:	Prof K Horne (TBC)			

AS5002 Magnetofluids and Space Plasmas

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Planned timetable:	11.00 am Mon, Tue, Thu (TBC)			
This module is aimed at both physics and astrophysics students with interests in the physics of plasmas. The interaction of a magnetic field with an ionized gas (or plasma) is fundamental to many problems in astrophysics, solar- terrestrial physics and efforts to harness fusion power using tokamaks. The syllabus comprises: Solar-like magnetic activity on other stars. The basic equations of magneto-hydrodynamics. Stellar coronae: X-ray properties and energetics of coronal loops. Energetics of magnetic field configurations. MHD waves and propagation of information. Solar and stellar dynamos: mean field models. Star formation: properties of magnetic cloud cores, magnetic support. Physics of accretion discs: transport of mass and angular momentum. Accretion on to compact objects and protostars. Rotation and magnetic fields in protostellar discs. Rotation distributions of young solar-type stars. Magnetic braking via a hot, magnetically channelled stellar wind.				
Programme module type:	Optional for Postgraduate programmes within the School of Physics & Astronomy.			
Pre-requisite(s):	Admission to a taught Postgraduate degree programme			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.			
Assessment pattern:	2-hour Written Examination = 100%			
Module coordinator:	Prof M M Jardine (TBC)			
Module teaching staff:	Prof M M Jardine (TBC)			

AS5003 Contemporary Astrophysics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Planned timetable:	12.00 noon Wed, Fri and 3.00 pm Mon (TBC)			
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:	Optional for Postgraduate programmes in the School.			
Pre-requisite(s):	Substantial astronomy knowledge and skills.			
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures and tutorials			
Assessment pattern:	2-hour Written Examination = 100%			
Module coordinator:	Dr H Zhao (TBC)			
Module teaching staff:	Dr A Sicilia-Aguilar, Dr P Rimmer, Dr A Mortier, Dr H Zhao (TBC)			

AS5521 Observational Techniques in Astrophysics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	Whole Year
Planned timetable:	Semester 1: Labs: 2.00 pm - 5.30 pm on Mon and Thu Semester 2: Lectures: 5.00 pm - 6.00 pm on Monday			
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. Projects in this part include structural analysis of galaxies and photometry of transiting exoplanet candidates. Observations are also secured using a student-built radio telescope to observe low-frequency radio emission from astronomical sources. The lecture part prepares the students for working with large-scale professional facilities and advanced observing techniques. The module is rounded off by hands-on observing training with the James Gregory Telescope in St Andrews and (optional) with telescopes overseas as part of a field trip. Overall, students gain valuable experience in observation, data analysis, astronomical software, observing techniques, report and proposal writing.				
Programme module type:	Optional for MSc in Astrophysics			
Pre-requisite(s):	BSc or equivalent in the physical sciences			
Learning and teaching methods and delivery:	**Weekly contact**: 7-hour practical classes (x 7 weeks), 1-hour Lectures (x 10 weeks), 15 hours of fieldwork.			
Assessment pattern:	Coursework = 100%			
Module coordinator:	Dr A Scholz			

AS5522 Stellar Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
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.

Programme module type:	Optional for MSc in Astrophysics
Pre-requisite(s):	AS4011 or equivalent from first degree
Co-requisite(s):	AS5500
Learning and teaching methods and delivery:	**Weekly contact**: 3-hours of lectures (x 11 weeks), 1-hour tutorials (x 5 weeks)
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Module coordinator:	Prof A Cameron
Module teaching staff:	Prof A Cameron, Dr P Wotike

AS5523 Gravitational Dynamics and Accretion Physics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
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.

Programme module type:	Optional for MSc in Astrophysics
Pre-requisite(s):	BSc or equivalent in the physical sciences
Co-requisite(s):	AS5500
Learning and teaching methods and delivery:	**Weekly contact:** 3-hour lectures (x 11 weeks), 48 hours of practical classes, 1-hour tutorials (x 5 weeks)
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Module coordinator:	Prof I Bonnell

AS5524 Astrophysical Fluid Dynamics

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	2
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.

Programme module type:	Optional for MSc in Astrophysics
Co-requisite(s):	AS5500
Learning and teaching methods and delivery:	**Weekly contact:** 3 hours of lectures (x 11 weeks), 5 x 1-hour tutorials over the semester
Assessment pattern:	2-hour Written Examination = 75%, Coursework = 25%
Module coordinator:	Prof M Jardine

PH5011 General Relativity

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Planned timetable:	9.00 am Wed, Fri, 3.00 pm Thu (TBC)			

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 Postgraduate programmes in the School
Pre-requisite(s):	Relevant mathematics and physics
Learning and teaching methods and delivery:	**Weekly contact**: 3 lectures or tutorials.
Assessment pattern:	2-hour Written Examination = 100%
Module coordinator:	Dr M Dominik

PH5023 Monte Carlo Radiation Transport Techniques

SCOTCAT Credits:	15	SCQF Level 11	**Semester:**	1
Planned timetable:	11.00 am Wed, 2.00 pm Tue, Fri (TBC)			

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

Programme module type:	Optional for Postgraduate programmes in the School.
Pre-requisite(s):	Relevant physics, mathematics and computing
Learning and teaching methods and delivery:	**Weekly contact**: 3 hours of lectures (x 6 weeks), 1-hour tutorials (x 5 weeks), during semester 3 x 3 hour supervised computer lab sessions
Assessment pattern:	Coursework (worksheets = 50%, 3-hour computing test = 25%, 1-hour Class Test = 25%) = 100%
Module coordinator:	Dr K Wood