UNIVERSITY OF LEICESTER

Module Specification

PA7011 Foundations of Professional Space Science & Engineering

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	16
Seminars	5
Practical Classes & Workshops	15
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	114
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 1
Occurence: A
Coordinator: Ian Hutchinson
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Examination (Final)	70		2		
002	Professional development portfolio	10				
003	Coursework	20				
101	Examination (Final)	100		2		Y

Intended Learning Outcomes

The module objective is instilling professional skills and disciplinary context from the very beginning of the MSc programme.
1.) Describe and explain the key scientific questions that space exploration seeks to answer.
2.) Explain the relationship with, and development of space engineering from other engineering disciplines with reference to the unique challenges of space and the key requirements on space systems.
3.) Demonstrate a range of practical scientific and engineering tasks in a laboratory setting.
4.) Produce, review and update a personal Professional Development Plan showing awareness of the competencies required to achieve registration with an appropriate professional body.
5.) Produce and maintain a reflective log of training and development activities undertaken.
6.) Describe the fundamental principles of planetary geology (including: planetary formation, planetary structure, magnetic fields, alteration processes and planetary biology)
7.) Demonstrate an awareness of the challenges posed by astronomy missions.

Teaching and Learning Methods

16 lectures/guest lectures introducing space exploration and engineering.
5 Seminars
15 hours of practical laboratory work.
Guided independent study/reflective tasks.

Assessment Methods

This module is assessed via an examination and coursework in the form of a laboratory report. Three separate pieces of assessment will be required. Students will also be required to produce a personal development plan, which will be reviewed at the end of the module and again at the end of the taught component of the course. Examination will be held in January.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

UNIVERSITY OF LEICESTER

Module Specification

PA7013 Spaceflight Dynamics and Propulsion

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	20
Seminars	
Practical Classes & Workshops	14
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	116
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 1
Occurence: A
Coordinator: Nigel Bannister
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Examination (Final)	70		2		
002	Coursework	30				
101	Examination (Final)	100		2		Y

Intended Learning Outcomes

At the end of this module:

1) Demonstrate knowledge of the fundamental physical and engineering principles appropriate to astronautics with specific emphasis on rocket propulsion and the ways this is applied to rocket engines.
2) They will be conversant with the design and operation of solid, and liquid fuelled chemical engines as a key spacecraft/ rocket sub-system.
3) They will understand the physics of electric and nuclear propulsion and be conversant with practical examples of each kind of thruster as a key spacecraft/rocket sub-system.
4) They will be able to solve numerical problems on rocket engine performance Students will be able to: understand forces' action on launcher and space vehicles; derive and use the rocket equation; understand thrust to weight ratio; solve numerical problems on launch and interplanetary transfer.
5) Students should: extract physical principles from requirements for space missions; calculate engineering requirements.
6) Demonstrate an advanced working knowledge of orbital mechanics.
7) Develop mission designs by addressing satellite control and maneuvers, transfer trajectories.
8) Proficiency in the use of software tools such as Satellite Tool Kit, which provides a virtual environment for mission design.
9) Demonstrate a broad awareness of the European space industry e.g. products and focus of the main large aerospace companies, policies and priorities of major contributors to ESA.
10) Select and apply appropriate mathematical models for use as 'hand calculations' in the concept or preliminary design of space mission, systems, sub-systems and instruments.

Teaching and Learning Methods

The module will adopt more traditional teaching methods in the form of 20 lectures, which will provide the theoretical basis for the more applied element of the course. This practical workshop activity involves mission design using the Satellite Tool Kit modeling environment.
Guided independent study/reflective tasks.

Assessment Methods

The module will be assessed by exam in January and a structured technical assessment of the Satellite Tool Kit workshop and training programme. In total 2 pieces of assessment will be required. The final workshop in the programme will be reserved for assessing the progress made by the students.

Pre-Requisites

Co-Requisites

Excluded Combinations

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PA7013 Spaceflight Dynamics and Propulsion

Guided Independent Study: Indicative Activities

Module Specification

PA7014 Space and Planetary Environment, Planetary Surfaces

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	22
Seminars	1
Practical Classes & Workshops	40
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	87
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Academic Year
Occurence: A
Coordinator: Richard Ambrosi
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Examination	50		2		
002	Coursework (final)	50				
101	Examination	100		2		Y

Intended Learning Outcomes

The module will focus on enabling students to respond to the design challenges posed by the space environment. The module will also cover the specific challenges of getting to and onto the surface of planets and planetary satellites.

1) Students will gain a greater insight into the interaction of radiation with matter in the context of solar system exploration with robots and humans.
2) Students will have an awareness of radiation dosimetry and radiation safety.
3) Basic proficiency in radiation environment modelling and use of appropriate software tools: including Monte Carlo modelling codes such as GEANT4. This includes radiation transport through simple shielding geometries and instruments.
4) Students will gain greater insight into the challenges of getting to and onto the surface of planets and planetary satellites.
5) Demonstrate knowledge of the fundamental physical and engineering principles appropriate to astronautics.
6) Demonstrate knowledge of the objectives of Space exploration and exploitation, and the achievements of key missions.
7) Describe and explain the scientific questions that space exploration seeks to answer.
8) Critically assess the strengths and weaknesses of space missions, systems, sub-systems or instruments.
9) Demonstrate an awareness of the near Earth environment.

Teaching and Learning Methods

The programme will include teaching sessions as well as practical radiation modeling workshops & problems. Seminar speakers with experience in mission modeling will also contribute to the programme. Guided independent study/reflective tasks.

Assessment Methods

Assessment will be split evenly between continuous assessment and an examination. Examination will be in January and students will be expected to hand in two pieces of coursework. Students will be required to deliver a technical report based on the outputs from the practical sessions and workshops as well as a short assignment report.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7015 Spacecraft Instrumentation for Space and Planetary Science

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	20
Seminars	
Practical Classes & Workshops	40
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	90
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 2
Occurence: A
Coordinator: Ian Hutchinson
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework (Final)	100				

Intended Learning Outcomes

1) Gain greater insight into instrument development and design for space and planetary science applications. This module will cover instrument systems for particle detection as well as a large part of the electromagnetic spectrum and will provide students will a greater knowledge of the complementary nature of instruments selected for a particular mission.
2) Explain how science requirements drive instrument selection, mission design and hence engineering requirements.
3) At the end of the module students will be equipped with the skills necessary to explore the design an instrument for a mission based on a set of science requirements.
4) Have a working knowledge of instrument systems by participating in a structured laboratory exercise.
5) Demonstrate knowledge of the objectives of Space exploration and exploitation, and the achievements of key missions.
6) State, explain and apply the key requirements (incl. science requirements) of space systems/missions.
7) Produce technical reports, present technical material to space industry standards.
8) Interpret results of experimental data to draw conclusions and recommend future work

Teaching and Learning Methods

The programme will include teaching sessions as well as practical laboratory sessions. Seminar speakers with experience in instrument development will also contribute to the programme.
Guided independent study/reflective tasks.

Assessment Methods

This module will be assessed by coursework only. The students will be required to design an instrument for a mission of their choice. The work will be done in small teams if possible and based on the number of students participating in the course. The coursework will include two pieces of assessment one will be in the form of a laboratory report.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7051 Human Spaceflight and Nuclear Systems

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	18
Seminars	6
Practical Classes & Workshops	
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	126
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 2
Occurence: A
Coordinator: Richard Ambrosi
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework (Human Space Flight)	50				
002	Coursework (Nuclear Power Systems) Final	50				

Intended Learning Outcomes

1) The module will provide students with a detailed overview of the specific requirements introduced by human spaceflight. Students will demonstrate knowledge of the fundamental physical and engineering principles appropriate to astronautics and objectives of space exploration.
2) Students will gain an appreciation for the challenges and opportunities that human spaceflight presents.
3) Explain the impact microgravity has on the human organism.
4) Demonstrate an awareness of radiation and micrometeoroid shielding requirements.
5) Demonstrate a broad awareness of the European space industry e.g. products, sensors, technologies, and focus of the main large aerospace companies, policies and priorities of major contributors to ESA.
6) Describe and explain the scientific questions that space exploration seeks to answer.
7) Discuss the wider implications of space exploration and exploitation for society.
The module will expose students the different types nuclear power and propulsion technologies that can be used in space.
8) Demonstrate knowledge of the fundamental working principles of space nuclear power and propulsion systems, design challenges and space missions enabled by these systems.
9) Apply a working knowledge of thermal engineering, mechanical engineering to critically analyse the advantages, disadvantages and challenges associated with space nuclear power systems in the context of space exploration missions.

Teaching and Learning Methods

This course will be focused on more traditional teaching methods with time dedicated to seminars and practical sessions. The course will be taught in part by two visiting honorary academic staff members from the US to cover the human spaceflight and space nuclear power systems. Additional experts external to the University of Leicester will be contributing seminar series.
The University of Leicester team working on space nuclear power systems will be actively involved in the course.
Students will be required to undertake a short study on a topic related to space nuclear power systems or human space flight.

Assessment Methods

The assessment will be coursework based and split evenly between human space flight and nuclear power systems. The assessment is likely to be in the form of assignments and group work. Two separate pieces of coursework will be included in the assessment.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

UNIVERSITY OF LEICESTER

Module Specification

PA7052 Advanced Spacecraft Engineering

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	
Seminars	
Practical Classes & Workshops	28
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	122
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 2
Occurence: A
Coordinator: Richard Ambrosi
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework (Final)	100				

Intended Learning Outcomes

The module objective is to equip students with the tools required to translate the objectives of a space exploration mission into a spacecraft system that will deliver on the science requirements balanced against the constraints of sound spacecraft engineering principles and the need to find innovative solutions to engineering challenges. Students will have the opportunity to work on typical spacecraft engineering problems in a series of applied interactive sessions, which will bring together all the mission and spacecraft/instrument design activities. The focus of the module will be engineering challenges associated with robotic exploration missions and the development of instruments or systems that are required to operate in these environments. The practical nature of the module will enable students to apply their knowledge of mechanical, thermal, electronics and software engineering; mission design and instrument development. Students will develop an appreciation for the complex environmental challenges associated with taking a spacecraft concept through multiple design and implementation phases to launch and operations.

1) Select and apply appropriate mathematical models or commercial analysis packages to allow detailed analysis of particular aspects of a space mission, system, sub-system or instrument.
2) Use and apply the European Cooperation for Space Standardization (ECSS), whichis an initiative established to develop a coherent, single set of user-friendly standards for usein all European space activities.
3) Develop, verify and validate models for novel situations (those not covered by selecting from 'standard' methods) appropriate for the stage of the project lifecycle.
4) Compile and perform standard systems engineering analyses such as technical budgets, trade-offs, safety/reliability analysis, risk registers.
5) Critically assess the strengths and weaknesses of space missions, systems, sub-systems or instruments.
6) Demonstrate knowledge of the fundamental physical and engineering principles appropriate to astronautics.
7) State and explain the key requirements (incl. science requirements) on space systems/missions.

Teaching and Learning Methods

This module will focus on a series of design workshops and practical classes interspersed with targeted teaching sessions.

Assessment Methods

Students will be assessed by coursework only. The performance of students will be assessed by adopting a gated review process commonly used in industry to determine what progress has been made in developing an instrument, system, spacecraft concept for a solar system exploration mission. Two separate pieces of coursework will be required. One will be in the form of a research assignment the second a technical report based on the practical sessions and workshops.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7081 Practical Programming

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	2
Seminars	
Practical Classes & Workshops	51
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	97
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 1
Occurence: A
Coordinator: Sergei Nayakshin
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Computer Practicals	50				
002	Programming Tasks (Final)	50				

Intended Learning Outcomes

At the end of this module, students should know the basic structure of R and Python programming languages, and be able to design, program and execute codes written in these languages. The key goal is to equip the student with skills necessary to actually use these languages for self-directed research or computation. Unlike proprietor software like IDL, Python and R is an open-source environment well suited for statistical analysis and producing graphical output.

Teaching and Learning Methods

Introductory Lecture, self-study of course materials, and 20 computing lab based workshops (2 hour each). The students will be given well documented workshop scripts, practical programming exercises, tasks and assignments to be completed during workshops.

Assessment Methods

Workshop attendance, the number of tasks completed during the workshop, short interviews
with students during the workshops to evaluate their understanding of programming methods learned, and finally assignments of simple computing/modelling tasks. The resulting code and output is submitted to and analysed and marked by the workshop leader.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7091 Major Project

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 60

Student Workload (hours)

Lectures	0
Seminars	0
Practical Classes & Workshops	0
Tutorials	0
Fieldwork	0
Project Supervision	0
Guided Independent Study	0
Demonstration	0
Supervised time in studio/workshop	0
Work Based Learning	0
Placement	0
Year Abroad	0
Total Module Hours	0

Period: Summer Term
Occurence: A17
Coordinator: Nigel Bannister
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Individual Report	60				
002	Review 1	10				
003	Review 2	10				
004	Review 3	10				
005	Group Mark for Project overall	10				

Intended Learning Outcomes

The project objective is to provide students with the opportunity to apply the knowledge and skills gained in the taught courses to a multidisciplinary design or research activity.

1) Demonstrate knowledge of how Space missions are developed and managed, including the complementary roles of systems engineering and project management.
2) Select and apply appropriate mathematical models or commercial analysis packages to allow detailed analysis of particular aspects of a space mission, system, sub-system or instrument.
3) Develop, verify and validate models for novel situations (those not covered by selecting from 'standard' methods) appropriate for the stage of the project lifecycle.
4) Compile and perform standard systems engineering analyses such as technical budgets, trade-offs, safety/reliability analysis, risk registers.
5) Compile basic aerospace project management constructs such as Work Package Breakdowns and Descriptions, Project plans (e.g. Gantt) and Organograms.
6) Undertake design and optimisation of missions, systems, sub-systems, instruments or components in teams that cross-disciplinary and cultural boundaries.
7) Communicate technical information effectively to the standards expected in the industry.
8) Critically appraise the applicability of models or design techniques at each stage of the system lifecycle.
9) Interpret the results of experimental, modelling or systems engineering data to draw conclusions or recommend future work.
10) Demonstrate professional responsibility for technical or management decisions affecting a wider project.
11) Produce and regularly reflect and review a personal Professional Development Plan and learning log of an appropriate standard to begin the journey towards eventual registration as a chartered professional (CPhys or CEng).

Teaching and Learning Methods

The project will consist of a mission, system, sub-system or element (e.g. an instrument) design activity conducted in a team environment, and in three phases. Depending on the scope of the project, the phases will either address different elements of the system or different phases of the system lifecycle. For example, a mission project will typically address different aspects of the mission up to phase A, whereas in development of a single element the phases will address different phases of the product lifecycle.

Each project phase will last approximately 6 weeks and conclude with a design review.

PA7091 Major Project

Assessment Methods

A project review typical of the aerospace industry will be undertaken at the end of each of the three phases of the project. Students will prepare written submissions and a presentation to a review panel of academic and industry representatives. Each student will be provided formative feedback and Review Actions / Review Item Discrepancies (RID) to be addressed for later submission in common with aerospace practice.

Each student will submit a project report. Markers will pay particular attention to how RIDs have been addressed. This deliverable is equivalent to the Masters thesis and represents the major individual element of the assessment.

The overall project will also be assessed and one overall group mark awarded to all the students. This is a small component of the assessment, but its inclusion is directly justified by ILO 10.

The minimum qualifying mark for the project is 50%.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7092 Optional Major Project International Placement: Space Exploration Development Systems (SEEDS)

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 60

Student Workload (hours)

Lectures	0
Seminars	0
Practical Classes & Workshops	0
Tutorials	0
Fieldwork	0
Project Supervision	0
Guided Independent Study	0
Demonstration	0
Supervised time in studio/workshop	0
Work Based Learning	0
Placement	0
Year Abroad	0
Total Module Hours	0

Period: Summer Term
Occurence: A17
Coordinator: Richard Ambrosi
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Individual Element/Sub-system report	60				
002	End of Phase 1 (Toulouse) design review	10				
003	End of Phase 2 (Torino) design review	10				
004	End of Phase 3 (Leicester) design review	10				
005	Group Mark for Overall Report	10				

Intended Learning Outcomes

The project objective is to provide students with the opportunity to apply the knowledge and skills gained in the taught courses to a multidisciplinary design or research activity in an international context, and to experience living and working abroad in a professional context.

Students completing this project will, in addition to the credits for the MSc award, receive a SEEDS Certificate of participation to demonstrate to future employers the unique professional development experience achieved by completing an international project.

1.) Demonstrate knowledge of how Space missions are developed and managed, including the complementary roles of systems engineering and project management.
2.) Select and apply appropriate mathematical models or commercial analysis packages to allow detailed analysis of particular aspects of a space mission, system, sub-system or instrument.
3.) Develop, verify and validate models for novel situations (those not covered by selecting from 'standard' methods) appropriate for the stage of the project lifecycle.
4.) Compile and perform standard systems engineering analyses such as technical budgets, trade-offs, safety/reliability analysis, risk registers.
5.) Compile basic aerospace project management constructs such as Work Package Breakdowns and Descriptions, Project plans (e.g. Gantt) and Organograms.
6.) Undertake design and optimisation of missions, systems, sub-systems, instruments or components in teams that cross disciplinary and cultural boundaries.
7.) Communicate technical information effectively to the standards expercted in the industry.
8.) Critically appraise the applicability of models or design techniques at each stage of the system lifecycle.
9.) Interpret the results of experimental, modelling or systems engineering data to draw conclusions or recommend future work.
10.) Demonstrate professional responsibility for technical or management decisions affecting a wider project.
11.) Demonstrate a broad awareness of the European space industry e.g. products and focus of the the main large aerospace companies, policies and priorities of major contributors to ESA.
12) Produce and regularly reflect and review a personal Professional Development Plan and learning log of an appropriate standard to begin the journey towards eventual registration as a chartered professional (CPhys or CEng).

PA7092 Optional Major Project International Placement: Space Exploration Development Systems (SEEDS)

Teaching and Learning Methods

The project consists of a team mission and system design activity to a comparable level of detail to a 'phase A' study conducted in industry. The project is completed in three phases, with students from the three institutes co-located at each of those institutes in turn. Each phase addressed one aspect of the system design.

The first phase of the project will be at Institut Supérieur de l'Aéronautique et de l'Espace, Toulouse, France, during April and May 2014, and will start with 2 weeks of team building and a comprehensive introduction to the project.

The second phase of the project will be conducted at Politecnico di Torino (Turn), Italy, during June and July 2014. There will be a 2 week summer break for all students before or after the Torino phase of the project.

The final phase of the project will be conducted at the University of Leicester in August and September 2014, and will include 2 weeks for project write-up.

A final presentation and award ceremony will follow the formal completion of the project. It is intended that this will be held at the European Space Agency in the Netherlands.

A Project Work Teaching Team (PWTT) will be formed from industry and academic personnel at each of the three locations to support all students during the project. During the project phases in Toulouse and Torino, University of Leicester students will also maintain regular contact with the module coordinator Dr X and their personal tutor at Leicester.

Assessment Methods

A project review typical of the aerospace industry will be undertaken at the end of each of the three phases of the project. Marking will consider both written contributions and aural presentation. The review team consisting of the local PWTT and a member of academic staff from the University of Leiecster will provide marks, formative feedback and Review Actions / Review Item Discrepancies (RID) to be addressed for later submission in common with aerospace practice.

Each student will take responsibility for a section of the main project report, which will be marked by University of Leicester acaemdic staff, who may nevertheless use input and guidance from colleagues at Toulouse and Torino as appropriate. Markers will pay particular attention to how RIDs have been addressed. This deliverable is equivalent to the Masters thesis.

The overall project report will also be assessed by University of Leicester staff, using input from Toulouse and Torino where appropriate, and the same overall group mark awarded to all the students. This is a small component of the assessment, but its inclusion is directly justified by ILO 10.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7111 Methods in Mathematical Physics

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	18
Seminars	
Practical Classes & Workshops	6
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	126
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 1
Occurence: A
Coordinator: Sergei Nayakshin
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Problem Assignment	15				
002	Portfolio	50				
003	Exam (Final)	35		1.25		

Intended Learning Outcomes

At the end of this module, typical students should be able to:
- Explain aspects of the scientific method, types of logical reasoning and data analysis
- Critically analyse statistical and scientific arguments
- Calculate and interpret common quantitative and graphical data summaries using statistical software
- Use the calculus of probability to manipulate basic probability functions
- Apply and interpret basic model fitting (e.g. maximum likelihood)
- Review classical mechanics. Master calculus of variations to solve simple variational problems. Derive the Lagrangian and Hamiltonian for a given dynamical system and solve the resultant equations of motion.

The syllabus covers:
1. inference in science
2. quantitative and graphical summaries of data
3. the calculus of probability
4. random variables
5. building a model and estimating its parameters
6. testing the model
7. review classical mechanics.
8. calculus of variations
9. Lagrangian and Hamiltonian mechanics

Teaching and Learning Methods

The course comprises taught lectures, supervised computer workshops and accompanying private study time, based around a workbook containing exercises and realistic data analysis projects. The lectures include several class-participation demonstrations that illustrate statistical ideas. Skills and experience are developed through hands-on analysis during workshops and private study. Case studies will include analysis of data from binary pulsars, particle detectors and classic data from Galileo (motion), Rutherford (radiation) and Michelson (speed of light). The emphasis is on practical calculation using statistical methods (rather than theory), making use of the popular, open-source statistical and data analysis environment R. This will be introduced during the lectures, workshops, and through the workbook. No prior knowledge of data analysis, statistics or R required.

Set texts and lectures; example problems and demonstrations during lectures.

Assessment Methods

Portfolio of completed workbook exercises and projects, problem assignments

Pre-Requisites

Co-Requisites

PA7111 Methods in Mathematical Physics

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7112 Applications in Theoretical Physics

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	15
Seminars	
Practical Classes & Workshops	15
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	120
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 2
Occurence: A
Coordinator: Sergei Nayakshin
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework	15				
002	Computing assignment	50				
003	Exam (final)	35		2.5		

Intended Learning Outcomes

At the end of this module, typical students should be able to:
- Demonstrate an understanding of statistical mechanics in the context of computer simualtions
- Develop equations for the thermodynamic properties of materials in terms of fundamental properties such as atomic potentials
- Use these equations in a numerical simulation1

- Design, write and implement an N-body code to trace the time evolution of a system of gravitating bodies in C++. Students should be able to clearly explain their approach to solving the problem and present the results of their investigation clearly in report form.

Syllabus

1. Statistical mechanics.
- Revision of classical mechanics.
- Applications: electron specific heat, equation of state of neutron star, black-body radiation.
- Phase space and its uses: the partition function. The Ergodic Hypothesis.
- Development of virial theorem and equation of state of interacting particle system.

2. Computer Simulations:
- Need for numerical results
- Molecular Dynamics: Solving the equations of motion
- Monte Carlo methods: random variables have uses!
- Data analysis: Reverse Monte Carlo

Teaching and Learning Methods

Taught lectures and problem assignments

Assessment Methods

Written examination and problem assignments

Pre-Requisites

PA7111

Co-Requisites

PA7112 Applications in Theoretical Physics

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7113 Particle Methods in Scientific Computing

Academic Year:	2017/8
Module Level:	Postgraduate
Scheme:	PG
Department:	Physics and Astronomy
Credits:	15

Student Workload (hours)

Lectures	8
Seminars	
Practical Classes & Workshops	25
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	117
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period:	Semester 2
Occurence:	A
Coordinator:	Walter Dehnen
Mark Scheme:	PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Project Programmin Tasks	25				
002	Written Report	25				
003	Presentation with Viva (Final)	50				

Intended Learning Outcomes

At the end of this module, typical students should have a good understanding of smoothed particle hydrodynamics (SPH) beyond the basic level. The students will have gained some practical experience in writing and running computer code for SPH and experimenting to get a feeling for the properties of the method.
Syllabus:
Unit 1
Eulerian vs Lagrangian fluid dynamics; the smoothing kernel and SPH density estimator; SPH derivatives; errors of SPH estimators; the discretised Euler equation; conservation properties; artificial dissipation terms; time integration.
Unit 2
stability and convergence of SPH; Conservative and non-conservative techniques; adaptive SPH; limitations of SPH; variants of SPH (weakly-compressible SPH, incompressible SPH);

Teaching and Learning Methods

Lectures, Practical individual projects based on specific computational tasks.

Assessment Methods

A written report (on the individual project) forms the basis of a 30min viva, which shall investigate the students understanding of the subject and their mastery of the particular project.

Pre-Requisites

Co-Requisites

Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7211 Practical Programming for Astrophysics

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	1
Seminars	
Practical Classes & Workshops	40
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	109
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 1
Occurence: A
Coordinator:
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Computing workshop assignments	70				
002	Numerical assignment	30				

Intended Learning Outcomes

The module will provide an introduction to the practical use of programming languages used in industry and academia (e.g. Python, C, C++) and will build on this knowledge to the cover the implementation of numerical techniques commonly used in astrophysics research.

At the end of the module, a typical student should be able to:
- amend, extend and improve existing codes in one or more of the languages,
- implement numerical procedures and data manipulation tasks in one or more of the languages,
- write up their own implementations, including a critique,
- present annotated codes in a professional way,
- develop code to apply numerical techniques commonly ecountered in astrohpysics research,
- develop code to present and analyse data in a variety of ways commonly used in astrophysics research.

Teaching and Learning Methods

Following an initial introductory lecture, the module is taught using downloadable workshops and a numerical assignment. The workshops take students through practical aspects of coding, starting with the amendment of existing codes, and eventually leading to the writing of codes from scratch. The workshops will take place in supervised computer labs and as guided independent study. Progression within each workshop is via a series of comptencey tasks that test basic computing skills or demonstrate expertise. The numerical assignemnt involves the development of code to apply specific numerical techniques to solve a set theoretical or data anaylsis problem in astrophysics.

Assessment Methods

Marking of e-notebooks and sign off of computational competency tasks. Computing assignment report: approx 2000 report, with working software.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7212 Advanced Astrophysics 1

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	38
Seminars	
Practical Classes & Workshops	3
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	109
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 1
Occurence: A
Coordinator:
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework	30				
002	Examination	70				

Intended Learning Outcomes

This module provides a grounding in the fields of stellar structure, stellar evolution and galaxies in the local Universe, covering fundamental concepts and observations and leading to a discussion of current research activity and trends.

At the end of this module, typical students should be able to describe and discuss the observational evidence that underpins theories of stellar structure and evolution; derive and apply the equations governing stellar structure; construct stellar models including the application of the relevant constitutive relations (pressure, opacity etc); discuss the limitations of stellar models; describe and discuss the observational evidence relating to the process of star formation; describe and interpret stellar evolutionary tracks in the H-R diagram; describe and discuss the principles of stellar evolution; discuss and predict the evolution of high and low mass stars; discuss and predict the evolution of stars within binary systems; describe and discuss observations of galaxies in the local Universe; describe and discuss the strucutre of galaxies and clusters of galaxies; describe and discuss the kinematics and dynamics of stars within galaxies.

Teaching and Learning Methods

Lectures, example problems, set problems, support sessions.

Assessment Methods

Examination, set problems.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7213 Astrophysical Data Analysis

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	12
Seminars	
Practical Classes & Workshops	12
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	126
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 1
Occurence: A
Coordinator:
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework	100				

Intended Learning Outcomes

This module provides a practical course in scientific data analysis and interpretation in a research context, using example data sets derived from a variety of common observational techniques across multiple astronomical wavebands.

At the end of this module, typical students should be able to:
- Explain aspects of the scientific method, types of logical reasoning and data analysis
- Critically analyse statistical and scientific arguments
- Calculate and interpret common quantitative and graphical data summaries using statistical software
- Use the calculus of probability to manipulate probability functions
- Apply and interpret basic model fitting (e.g. maximum likelihood)
- Discuss and describe the reduction of astrophysical data in a variety of contexts and wavebands (e.g. optical photometry, X-ray spectroscopy)
- Reduce and analyse example astrophysical datasets using standard software packages (e.g. IRAF, XSPEC) over multiple wavelengths
- Intrepret results from common observational techniques used in astrophysics research (e.g. photometry, spectroscopy) at multiple wavelengths

Teaching and Learning Methods

Lectures, computational workshops, example problems, set problems, computational projects, support sessions.

Assessment Methods

Portfolio of completed workbook exercises and projects.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities

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Module Specification

PA7214 Advanced Astrophysics 2

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	29
Seminars	
Practical Classes & Workshops	
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	121
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 1
Occurence: A
Coordinator:
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework	30				
002	Examination	70				

Intended Learning Outcomes

This module provides a grounding in the fields of general relativity, extrasolar planets and life in the Universe, the module covers the fundamental concepts and observations and leads to a discussion of current research activity and trends.

At the end of this module, typical students should be able to state the physical principles underlying general relativity (equivalence principle and special relativity); explain how these are formulated mathematically in terms of curved space-time; give a quantitative account of some of the experimental support for the theory; discuss the Schwarzschild solution for a spherical gravitational field and derive its properties; recognize the Kerr solution and derive some simple properties; describe quantitatively some basic features of black holes including thermal properties.

At the end of this module, typical students should be able to describe and discuss the observational techniques invoolved with the search for extrasolar planets; describe, discuss and interpret the distributions of the physical parameters of the known extrasolar planetary systems; describe and discuss various theories for the origin of life; discuss these theories in the context of known extrasolar planetary systems; describe and discuss various means of searching for life within the Solar System and beyond.

Teaching and Learning Methods

Lectures, example problems, set problems, support sessions.

Assessment Methods

Examination, set problems.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7221 Advanced Astrophysics 3

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	30
Seminars	
Practical Classes & Workshops	
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	120
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 2
Occurence: A
Coordinator:
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework	30				
002	Examination	70				

Intended Learning Outcomes

This module provides a grounding in the fields of accretion physics and accretion discs with a specific focus on the contexts of active galactic nuclei and protoplanetary discs. The module covers the fundamental concepts and observations and leads to a discussion of current research activity and trends.

At the end of this module, typical students should be able to discuss and describe the physical processes involved in astrophysical accretion; solve problems involving the physics of accretion flows and discs; describe and discuss the observed properties of AGN and the associated theoretical models; show how fundamental parameters of AGN, such as central black hole mass and radius, can be determined by observations; quantitatively describe and solve problems involvling accretion on to supermassive black holes and the resulting environmental feedback and its consequences; describe and discuss observational evidence for and physical processes associated with current theories of planet formation; describe and discuss conditions and processes within protoplanetary accretion discs; solve problems involving protoplanets and protoplanetary discs. Students should able to breakdown a complex problem in order to identify its essential elements, apply prior knowledge to analyse a problem, implement a planned solution that addresses a problem, evaluate a solution and reflect upon it.

Teaching and Learning Methods

Lectures, example problems, set problems, support sessions.

Assessment Methods

Examination, set problems.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7222 Advanced Astrophysics 4

Academic Year:	2017/8
Module Level:	Postgraduate
Scheme:	PG
Department:	Physics and Astronomy
Credits:	15

Student Workload (hours)

Lectures	30
Seminars	
Practical Classes & Workshops	
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	120
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period:	Semester 2
Occurence:	A
Coordinator:	
Mark Scheme:	PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework	30				
002	Examination	70				

Intended Learning Outcomes

This module provides a grounding in the fields of cosmology and cosmological structures, covering fundamental concepts and observations and leading to a discussion of current research activity and trends.

At the end of this module, typical students should also be able to describe and discuss the observational facts of cosmology; describe and discuss theoretical models of the Universe that are based on the general theory of relativity and the cosmological principle; explainsome of the successes of the theory in interpreting observations and some of the unresolved issues; quantitatively describe observations of large scale structure in the Universe; state and manipulate the equations for the growth of gravitational instabilities in an expanding Universe; understand the relationship between the evolution of large scale structure and various cosmological parameters and the constituents of the Universe; understand the relevance of radiation and dissipation in the formation of galaxies and clusters of galaxies.

Teaching and Learning Methods

Lectures, example problems, set problems, support sessions.

Assessment Methods

Examination, set problems.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7223 Journal of Astrophysical Topics

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	1
Seminars	16
Practical Classes & Workshops	
Tutorials	
Fieldwork	
Project Supervision	
Guided Independent Study	133
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 2
Occurence: A
Coordinator:
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework	100				

Intended Learning Outcomes

This module introduces students to scientific publishing and peer review in the context of astrophysics researc. Students act as authors, referees, and editors of their own scientific journal: working in small research teams, students are required to generate original ideas for research, write short scientific papers and peer-review the work of other groups. The publication process is overseen by a student editorial board with rotating membership. Professional Open Journal Systems software is used to run the submission, review and publication processes of the journal online and students' published work is made publicly available from the journal website.

At the end of this module, typical students should be able to: formulate new astrophysics problems; write concise scientific articles and referee reports; communicate scientific results to peers and to the press; understand the formal processes (authoring, reviewing and editing) involved in scientific publishing; use the open journal systems, journal management and publishing software.

Teaching and Learning Methods

Introductory session; guided group work on writing and reviewing scientific articles; editorial board meetings; workshop on scientific writing.

Assessment Methods

The final module percentage for each student group is calculated according to the quantity and quality of accepted publications in the journal, and a group ranking. The group ranking is derived from each group's awarded journal points, which are awarded for paper submission (0-1), paper publication (2-5), and referee reports (0-1). Students must keep and submit a CV of publications and contributions.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7224 Astrophysics Study Project

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 15

Student Workload (hours)

Lectures	1
Seminars	
Practical Classes & Workshops	
Tutorials	
Fieldwork	
Project Supervision	10
Guided Independent Study	139
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	150

Period: Semester 2
Occurence: A
Coordinator:
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Coursework	100				

Intended Learning Outcomes

This module requires students to undertake a literature review in one of a set number of topics of current astrophysics research.

At the end of this module, typical students should be able to:
- Prepare a research report on a self-contained topic in astrophysics. The report will be a review-style summary of the topic; this may take the form of a study report, a review article, or a review chapter depending on the nature of the topic. In addition to the main report text, it will include a brief abstract of the topic; a brief review of how the material was gathered; a list of works studied with short notes on each and follow-up references.
- Prepare a research presentation at advanced undergraduate/beginning graduate level lasting about 20 minutes with 5 minutes for questions.
- Prepare for responding to questions akin to those expected after a research seminar.
- Produce written material in preBcis; describe scientific results in an accessible but rigorous manner; communicate ideas and arguments effectively in written format; ensure that the structure and length of written work is appropriate.
- Make verbal presentations that communicate information, ideas and arguments effectively to a audience at the advanced undergraduate/beginning postgraduate level; demonstrate an ability to choose a format and language appropriate to such an audience; use appropriate presentation aids to enhance the quality and clarity of the presentation.
- Develop strategies for locating and accessing information; compare and evaluate information obtained from different sources; synthesise and build upon existing information.

Teaching and Learning Methods

Introductory lecture; individual guidance via module supervisor; presentation sessions.

Assessment Methods

Research progress, report of approx 5000 words and final presentation.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities

Module Specification

PA7231 Advanced Astrophysics Research Project

Academic Year: 2017/8
Module Level: Postgraduate
Scheme: PG
Department: Physics and Astronomy
Credits: 60

Student Workload (hours)

Lectures	1
Seminars	
Practical Classes & Workshops	
Tutorials	
Fieldwork	
Project Supervision	12
Guided Independent Study	587
Demonstration	
Supervised time in studio/workshop	
Work Based Learning	
Placement	
Year Abroad	
Total Module Hours	600

Period: Semester 2
Occurence: A17
Coordinator:
Mark Scheme: PGT Module Mark Scheme

No.	Assessment Description	Weight %	Qual Mark	Exam Hours	Ass't Group	Alt Reass't
001	Progress	20				
002	Presentation	30				
003	Dissertation	50				

Intended Learning Outcomes

This module requires students to plan, manage and deliver a small progamme of research in astrophysics, working as an individual researcher under supervion.

At the end of this module, typical students should be able to design, implement and deliver an original investigation in an area of astrophysics as an individual researcher under supervision. .

Teaching and Learning Methods

Supervised research. Induction session, handbooks, interactive supervision.

Assessment Methods

The module will be assessed according to the progress on the project, a dissertation of approx 10000 words and a 30 min presentation.

Pre-Requisites

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Co-Requisites

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Excluded Combinations

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Guided Independent Study: Indicative Activities