Structured PhD programme in Physics at NUI Galway

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Overview
The School of Physics has received approval for the following graduate programme in Physics.

In addition to the PhD thesis, graduate students will be required to successfully complete a minimum number of approved modules consisting of 30 ECTS (4 years) and 20 ECTS (3 years).

It is envisaged that students participating in the structured PhD programme in the School of Physics at NUI Galway will take core modules as outlined below. In addition students will also choose elective modules based on generic / transferrable skills or in discipline-specific courses.

The core modules are approved by the graduate studies board.

Regarding transferable skills, the School of Physics is offering four new scientific computing courses in collaboration with the Irish Centre for High End Computing (ICHEC). It is envisaged that these courses will be offered nationally via the IUA agreement. The details are below.

The School of Physics also proposes a research placement programme as an elective under transferrable skills. This has been approved as a general GS module by the Graduate Studies Board.

Regarding discipline –specific courses, the School of Physics has proposed two modules, in optics and aerosol science, the delivery for which will be folded into the work load model of the School. It is envisaged that these courses will also be offered nationally via the IUA agreement.

It is expected that graduate students at the School of Physics will take courses accredited and delivered by other Schools and Colleges (within NUI Galway) and with other academic institutions within Ireland and Europe. As the details for these graduate courses are currently being prepared, the options provided under the INSPIRE PRTLI 5 programme, the Dublin Regional Higher Educational Alliance (DRHEA) and the Scottish University Physics Alliance (SUPA) are listed for information purposes in the appendix 1. Over the next few months, it is proposed to identify which courses are most suitable to the research programmes at the School of Physics.

PRTLI 5 INSPIRE
The School will implement the structured PhD in nanoscience at NUI Galway, funded under INSPIRE in PRTLI cycle 5, through the structured PhD in Physics, outlined in this document. PhD opportunities will be advertised as being in nanoscience but will be administered through the School of Physics, and using the single entry for structured PhDs at College level.

A summary of the structured PhD in Physic is given as follows:

Graduate studies modules for school of physics	ECTS	Code	Responsible
Core modules			
Graduate Information Skills (for Science, Engineering & Informatics, Medicine, Nursing & Health Sciences)	5	GS504	Library with Chair, RGE Committee, Physics
Graduate Research Skills	5	GS505	Chair, RGE Committee, Physics
Teaching & Learning	5	GS506	CELT NUI Galway
Elective modules in transferable skills			
Statistical Methods for Research	5	GS507	Mathematics
Journal club programme	5	GS502	Research cluster / group
Research Placement	5	GS 511/6	Research supervisor
Scientific Programming Concepts	5	PH502	ICHEC
Software Design & Carpentry for Scientists	5	PH504	ICHEC
High Performance Computing & Parallel Programming	5	PH503	ICHEC
Scientific Computing using GPUs (Graphics Processor Units)	5	PH503	ICHEC
Elective discipline – specific modules	5		
Optical Design & Image Formation	5	PH506	School of Physics
Physics of Aerosols and Particulate Matter	5	PH507	School of Physics
Nano-biomaterials	5	CH508	School of Chemistry

Core modules

Graduate Studies Form for Modules attached to Structured PhD	
Title	**Graduate Information Skills:** Critical methods and approaches in targeting, managing, publishing and disseminating research.
Credits (ECTS)	5
Module Places	Available to all new entrant / year 1 PhD candidates affiliated to the Colleges of: • **Science** • **Engineering & Informatics** • **Medicine, Nursing & Health Sciences**
Course Instance	
Module Code:	GS504
Please indicate if generic (GS) or specialised module	Incorporating a blend of generic (GS) and discipline specific units as appropriate.
Elective Places	

Indicative Module Descriptor:
This module aims to enable students to develop and acquire a range of generic and discipline specific research skills and gain an understanding of their practical application to the research process, in order to successfully complete fourth level research.

The module will be delivered in the 1st and 2nd semesters and delivery will incorporate a blended learning approach including participant attendance at face-to-face units incorporating both generic and discipline specific themes and utilisation of supporting online courseware available via Blackboard.

By the end of this module, the student is expected to be able to:

- Demonstrate the ability to identify, access and critically evaluate appropriate information resources relevant to their discipline
- Demonstrate the use of practical skills in the effective management of their research information
- Demonstrate an ability to keep up-to-date with new information quickly and conveniently
- Understand the scholarly communications and publications processes as well as key research evaluation methodologies in order to develop an informed publications strategy
- Understand the significance and implications of Intellectual Property, in particular copyright and knowledge transfer crucial to effective research and development.
- Develop skills for producing scientific reports and papers for scholarly journals

Workload:	
Class Contact	Contact hours: • Total 6-9 hours of which a minimum of 3 hours will be in the form of a face-to-face ½ day workshop and the remaining hours selected from either face-to-face or online self-paced learning units.
Workshop (other forms of educational activity)	• Required attendance at relevant discipline-specific *Getting Started on Your PhD* ½ day workshop • Plus attendance at a range of optional face-to-face workshops or self-directed learning via appropriate online modules, including generic and discipline specific themes.
Specified Assignment(s)	Aligned to the student's PhD research question in which they will undertake a comprehensive review of

	the existing literature in their area, module participants will be required to: 1. Submit a semi-structured literature review strategy outlining the best practice processes and techniques they will employ to locate, manage and assimilate current and ongoing research in their area. (Assessor: Rosarie Coughlan) 2. Submit a preliminary review article/paper providing a systematic review of the literature in their field. This should be of appropriate standard for potential publication and/or integration into their doctoral thesis. (Assessor: PhD Supervisor) 3. Maintain a reflective blog/journal (via Blackboard) outlining and tracking the processes and methods used to achieve the literature review (Assessor: Rosarie Coughlan) 4. Submit a list of formatted references demonstrating effective use of bibliographic management software (e.g. EndNote, BibTeX) to generate in-text citations in the preferred citation style of their College/discipline. (Assessor: Rosarie Coughlan).
Autonomous Student Learning *(please specify)*	Following attendance at relevant workshops and / or use of online courseware, students will be expected to undertake independent practical application of knowledge, skills and techniques explored in order to: • Produce a comprehensive, transparent and potentially replicable review of existing and ongoing knowledge in their field • Effectively manage the scope of literature acquired throughout the research process • Keep up-to-date with advancements in their field • Develop an informed and appropriate publication strategy • Demonstrate appropriate knowledge and understanding of IP, knowledge transfer and other aspects crucial to effective research and development.

Assessment(s) *(choose from below or add your own)*

	Type	% of marks	Timing
• Preliminary review paper outlining the existing *state of the art* in their area of research • Report documenting an effective literature review strategy • Reflective blog entries • Supporting formatted bibliography of research reviewed		**100%**	
Result		Pass / Fail	

Graduate Studies Form for Modules attached to Structured PhD	
Title	Graduate Research Skills
Credits (ECTS)	5
Module Places	Available to all new entrant / year 1 PhD candidates affiliated to the Colleges of: • Science • Engineering & Informatics • Medicine, Nursing & Health Sciences
Course Instance	
Module Code:	GS 505
Please indicate if generic (GS) or specialised module	Incorporating a blend of generic (GS) and discipline specific units as appropriate.

Indicative Module Descriptor:
This module aims to enable students to develop and acquire a range of generic and discipline specific research skills and gain an understanding of their practical application to the research process, in order to successfully complete fourth level research.

The module will be delivered over four semesters of the PhD programme and delivery will incorporate a blended learning approach including participant attendance at face-to-face units incorporating both generic and discipline specific themes and utilisation of supporting online courseware available via Blackboard.

By the end of this module, the student is expected to be able to:

- Demonstrate the ability to identify, access and critically evaluate the requisite specialised skills, technical training, and specialised diagnostic or other equipment required to carry out their research project
- Demonstrate the ability to write regular comprehensive reports of their research/ laboratory activities
- Demonstrate an ability to prepare and document annual plans that indicate their detailed strategy for the succeeding phases of the research
- Demonstrate an ability to exploit the extensive patent databases and to benchmark their research activity against the relevant patent literature
- Demonstrate an ability to communicate their data or findings in poster format and to a peer audience in the discipline
- Demonstrate an understanding of the importance of a notarised notebook as a record of their original contributions to research

Workload:

Class Contact	Contact hours: • Total 6-9 hours of which a minimum of 3 hours will be in the form of a face-to-face ½ day workshop and the remaining hours selected from either face-to-face or online self-paced learning units.
Workshop (other forms of educational activity)	• Required attendance at relevant discipline-specific *Getting Started on Your PhD* ½ day workshop • Plus attendance at a range of optional face-to-face workshops or self-directed learning via appropriate online modules, including generic and discipline specific themes.
Specified Assignment(s)	Aligned to the student's PhD research question, module participants will be required to: 1. Submit 2 referenced annual reports of their research progress (including projected future

	research activity plans) (Assessor: Graduate Research Committee) 2. Prepare a presentation on their work for presentation to a peer-audience in their discipline. (Assessor: Graduate Research Committee) 3. Maintain a reflective blog/journal (via Blackboard) outlining and tracking the processes and methods used to progress their research (Assessor: PhD Supervisor)
Autonomous Student Learning	Following attendance at relevant workshops and / or use of online courseware, students will be expected to undertake independent research activities and apply their knowledge and skills in order to: • Produce comprehensive annual reports of their research, appropriately referenced and calibrated against recent work in their field. • Identify their needs for training in new techniques, and for access to facilities, information, and software, in order to complete their research. • Keep up-to-date with advances in their field • Develop an informed and appropriate strategy for upgrading their technical skills • Maintain a notarised notebook of their research activity.

Assessment(s)

	Type	% of marks	Timing
• Annual reports outlining research progress and a critical assessment of training and other needs • Annual presentation to peer audience, describing their research progress and their plan for the completion of their project • Reflective blog entries • A well-structured research notebook, regularly updated and signed	**100%**		
Result	Pass / Fail		

Graduate Studies Form for Modules attached to Structured PhD	
Title	Teaching & Learning
Credits (ECTS)	5
Supervisor Approval	Supervisor approval is not a pre-requisite for this module due to teaching contribution of 120 hours per year (section 5.7 Duties)
Module Places	
Module Code:	GS506
Elective Places	

Indicative Module Descriptor:

This module will provide a comprehensive introduction to aspects of teaching and learning in higher education, offering an overview of basic ideas such as learning outcomes, teaching methods, assessment and approaches to learning. It will build experience of self-reflection through teaching practice, the identification of critical incidents and the use of a range of approaches to evaluation. All participants must undertake appropriate teaching practice, whether through tutoring, leading seminars or laboratory demonstration.

Indicative Learning Outcomes:
On successful completion of this module, students should;

- demonstrate awareness of the range of possible approaches to teaching and the promotion of active student learning available in higher education contexts;
- demonstrate awareness of the contextual factors and challenges which impact on an effective teaching and learning experience and identify some strategies for dealing with some common difficulties that may arise
- demonstrate appreciation of the particular role and responsibilities of the tutor or demonstrator;
- acquire significant experience in teaching and supporting learning in undergraduate (or postgraduate, if appropriate) programmes;
- have utilised appropriate approaches (including peer/mentor observation) to evaluate teaching;
- be able to reflect on critical incidents and learning events and evaluate the success or otherwise of particular approaches to teaching in the courses which they are supporting;
- have completed a reflective journal detailing their experiences and making suggestions and recommendations for subsequent improvement of their own performance and that of the students in their classes.

Structure:
This module will be delivered following a blended learning model which consists of three primary components:

- Online materials (in the Blackboard site for the module) and guided reading;
- Two three-hour workshops (one per semester) with associated activities and discussion;
- Reflection and peer discussion based on teaching practice as a tutor, laboratory demonstrator or in a similar capacity.
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Assessment(s):
The module will be assessed on a pass/fail basis following completion, to an appropriate standard, of the following:

- A reflective journal providing evidence of reflection, improved practice and evaluation of student learning;
- Completion of an acceptable level of teaching hours, evidenced by a detailed log over the appropriate period;
- Active participation in, and completion of associated tasks, the workshops and online course materials/exercises (which will include some short written contributions).

<table>
<tr><td colspan="4">

- A peer-assessment review of teaching

</td></tr>
<tr><td colspan="4">Workload: (specify or delete as appropriate)</td></tr>
<tr><td>Class Contact</td><td colspan="3"></td></tr>
<tr><td>Workshop</td><td colspan="3">6 hours</td></tr>
<tr><td>Specified Assignment(s)</td><td colspan="3">Portfolio to include (as appropriate to the Teaching responsibilities) elements such as:
➢ Reflective Journal
➢ Teaching Log
➢ Peer-Assessment/Observation or critical review of a Laboratory Teaching session
➢ Series of specific teaching experience exercises/tasks based on online materials</td></tr>
<tr><td>Autonomous Student Learning
(please specify)</td><td colspan="3">Extensive online materials and lessons
Teaching Practice
Series of readings from text, papers, reports and websites.</td></tr>
<tr><td colspan="4">Assessment(s) (choose from below or add your own)</td></tr>
<tr><td></td><td>Type</td><td>% of marks</td><td>Timing</td></tr>
<tr><td>Assignments
Reports
Oral or Written Presentations as appropriate</td><td colspan="3">100%</td></tr>
<tr><td>Result Successful completion of assignments from workshops and literature assignment</td><td colspan="3">Pass</td></tr>
</table>

Elective Modules in Transferable Skills.

Graduate Studies Form for Modules attached to Structured PhD	
Title	Statistical Methods for Research
Credits (ECTS)	5
Module Places	23
Module Code:	GS507
Elective Places	23

Indicative Module Descriptor:

The module aims to give students with little or no previous knowledge of statistics the opportunity to develop an understanding of the basic principles underlying these subjects, and to develop an excellent working knowledge of how to perform the following statistical techniques:

- Elementary Probability techniques
- Data summarisation and presentation
- Hypothesis testing, especially in relation to test of means.
- Correlation and linear Regression
- Study Design

Students will also be introduced to more advanced techniques, for example multivariate analysis and logistic regression.
Throughout, emphasis will be on practical application of the techniques learned.
Students will be encouraged to bring in data from there own research projects.
Approximately half of the time spent on the course will be devoted to implementing the above techniques using a statistical software package such as Minitab. Upon completion of the course, students will be able to apply the above techniques to their own research data, and will have developed a statistical platform on which they may easily extend their knowledge to more advanced statistical techniques.

Indicative Learning Outcomes:
On successful completion of this module, students should be able to:

- Summarise data numerically and graphically
- Understand the ideas underlying interval estimation and hypothesis testing
- Identify and perform the various hypothesis tests suitable for a particular analysis
- Understand the principles of correlation and regression
- Detect violations of the principles underlying various statistical techniques, and suggest remedial measures.
- Use Minitab (or a similar statistical package) to perform a wide range of statistical tasks.

Workload: *(specify or delete as appropriate)*

Class Contact	35 hours of lectures and discussion
Workshop	30 hours of computer lab and other sessions
Specified Assignment(s)	Homework and Laboratory assignments
Autonomous Student Learning	Supplementary lecture material and other text and web references will be given.

Assessment(s)

	Type	% of marks	Timing
Assessment will be by a brief oral examination	**100%**		
Result	Pass / Fail		

Graduate Studies Form for Modules attached to Structured PhD	
Title	Journal club programme
Credits (ECTS)	5
Module Places	
Module Code:	GS502
Elective Places	

Indicative Module Descriptor:
In this module the students will attend a series of journal clubs.
Students will participate in a minimum of 12 journal clubs (including one journal club at which they will present a paper).

The module aims to give students the opportunity to;

- Further their knowledge in diverse research areas
- Develop critical analysis skills
- Develop presentation skills

Indicative Learning Outcomes:
On successful completion of this module, students should ….

- Have learnt about current topics having attended a series of journal clubs covering diverse range of subject matter
- Gained experience in critical analysis of speakers at journal clubs
- Become experienced in presenting a research paper
- Become experienced in active discussion of research papers

Workload: *(specify or delete as appropriate) 100*

Class Contact: Journal club attendance	12
Workshop	
Specified Assignment(s) Preparation/presentation of students own journal club paper	18
Autonomous Student Learning Reflective journal • Evidence of critical preparation prior to attendance • Generation of pertinent questions • Reflection of journal club proceedings Reading research papers	55 15

Assessment(s)
Evidence of participation (signing sheet). Presentation at one journal club. Completion of reflective journal comprised of the bullet points mentioned above (suggested: approx 5h time investment per journal club attended).

	Type	% of marks	Timing
Year 1: Journal club attendance Assessment of reflective journal	Mandatory 100%		
Result	Pass 65% / Fail		

Graduate Studies Form for Modules attached to Structured PhD	
Title	Research Placement
Credits (ECTS)	5
Module Places	This is an elective module and placement must be organised by supervisor and agreed with a host.
Module Code:	GS511
Elective Places	See above

Indicative Module Descriptor:
Occasionally a graduate student may need to visit an academic or research laboratory outside NUI Galway to obtain training in a technique or extended access to specialised equipment for sample preparation or appropriate field-work. The student may spend from one to six months in this training placement. On longer placements, in addition to training, the student would also be expected to gather research results that would form of his/her final thesis. The supervisor should set out specific learning outcomes as goals to be achieved during the placement.

The module aims to give students the opportunity to;

- Further their knowledge in diverse research areas
- Develop critical analysis skills
- Develop presentation skills

Indicative Learning Outcomes:
On successful completion of this module, students should be able to:

- Demonstrate new knowledge and skills to the satisfaction of the supervisor in the placement institution.
- Exchange new knowledge and skills between the host research group/discipline/school of origin and the sending research laboratory at NUI Galway.

Workload: *(specify or delete as appropriate) 100*

Class Contact: Minimum placement period	1 Month
Workshop	
Specified Assignment(s) Research or training activity at host site. Presentation during or after placement at host site or at sending institution on return.	
Autonomous Student Learning Research or training activity at host site The student will prepare a report to include : (i) a statement about the training / research performed. (ii) evidence of the training / research result obtained. (iii) evidence that they exploited the training or research. A short presentation to a group/school audience within 2 months after returning to NUI Galway is expected.	

Assessment(s)
Graduate research committee to consider performance of student in consultation with host site

	Type	% of marks	Timing
Year 1: Assessment of reflective journal	100%		

Result	Pass / Fail

Graduate Studies Form for Modules attached to Structured PhD and/or Research Masters Programmes	
Title	Scientific Programming Concepts
Credits (ECTS)	5
Module Places	20
Module Code:	PH502
Elective Places	20

Indicative Module Descriptor:

This module is an introduction to programming concepts aimed at scientists who have had minimal or no formal training in the subject. The focus is on C and Fortran yet the general concepts should be applicable to other programming languages.

- Overview of computer architecture
- The UNIX/Linux shell
- The imperative programming paradigm
- Data types & arithmetic operations
- Loops & conditional statements
- Object-oriented programming
- Standard libraries
- Compilation
- C pointers & memory management
- Modern Fortran
- Scripting languages
- Introduction to HPC

Indicative Learning Outcomes:

On successful completion of this module, students should be able to:

- Gain an understanding of what constitutes a computer program and how it is constructed.
- Comprehend written source code.
- Write and compile basic programs in C/Fortran.
- Make use of standard libraries in own code.

Workload: *(specify or delete as appropriate) : Semester 2 (2011-2012);*

Class Contact (via e-learning)	12 lectures, available via VC Polycom *Classes; Thursdays 11.00 - 13.00* *Week 1 is Jan 30th for 9 weeks*
Workshop / tutorial	4 (x 2-3 hour) practical sessions *Labs Thursdays 14.00-1700 weeks 3,5,7& 9*
Specified Assignment(s)	4 practical assignments
Autonomous Student Learning	Supplementary lecture material and reading list will be given.

Assessment(s)

	Type	**% of marks**	**Timing**
Test 1	MCQ	0%	Start
Test 2	MCQ	10%	Middle
Test 3	MCQ	10%	End
Total MCQ		**20%**	
4 x assignments (20% each)		**80%**	
Result		Pass / Fail	

Graduate Studies Form for Modules attached to Structured PhD and/or Research Masters Programmes	
Title	Software Design & Carpentry for Scientists
Credits (ECTS)	5
Module Places	20
Module Code:	PH503
Elective Places	20

Indicative Module Descriptor:

This course will introduce the fundamentals of scientific software engineering through tools and techniques that enhance the design, development, execution and testing phases of the software life cycle. Particular emphasis will be placed on correct program design and its efficient, organised and robust implementation. Topics to be covered include:

- Introduction to scientific programming
- The Python scripting language
- Databases and SQL
- Program design using pseudo-code, fundamental programming constructs and concepts
- Software development methodologies
- Source code management using editors, version control
- Automated builds and code pre-processing
- Structured code testing and exception handling
- Code documentation
- Optimisation techniques: efficient data structure storage, looping and data dependency analysis and compiler optimisations
- Basic debugging, profiling and memory leak detection

Indicative Learning Outcomes:

On successful completion of this module, students should be able to:

- Implement program designs to write robust and reusable codes.
- Demonstrate effective management of a software development project using version control and automated build tools.
- Apply robust testing regimes in the development of codes and provide satisfactory documentation
- Analyse 'simple' scientific codes and suggest methods that help optimise memory and execution performance
- Describe the debugging and profiling processes and demonstrate their usefulness in software development

Workload: *(specify or delete as appropriate)*

Class Contact (via e-learning)	12 lectures. Material also available on-line
Workshop / tutorial	4 (x 2-3 hour) practical sessions
Specified Assignment(s)	2 assignments; 1 group project
Autonomous Student Learning	Supplementary lecture material and reading list will be given.

Assessment(s)

	Type	**% of marks**	**Timing**
Test 1	MCQ	0%	Start
Test 2	MCQ	10%	Middle
Test 3	MCQ	10%	End
Total MCQ		**20%**	
2 x assignments (20% each)		**40%**	

1 x group project	**40%**
Result	Pass / Fail

Graduate Studies Form for Modules attached to Structured PhD and/or Research Masters Programmes

Title	High Performance Computing & Parallel Programming
Credits (ECTS)	5
Module Places	20
Module Code:	PH504
Elective Places	20

Indicative Module Descriptor:

This module introduces key topics in high performance computing (HPC), including parallel programming. Prior programming experience; basic knowledge of UNIX/Linux shell is expected.

- Evolution of computer architecture
- High performance computing concepts and scientific applications
- Parallel decomposition
- Shared memory multiprocessing programming (OpenMP)
- The Message Passing Interface (MPI)
- Hybrid programming (OpenMP + MPI)
- Numerical libraries & high performance I/O libraries (e.g. NetCDF, HDF5)
- Introduction to multi-threading accelerators

Indicative Learning Outcomes:

On successful completion of this module, students should be able to:

- Understand key HPC concepts and how they are applied in scientific research.
- Devise parallel strategies to solve computational problems.
- Develop basic parallel applications using OpenMP and/or MPI.
- Leverage numerical, I/O libraries for better performing code.

Workload: *(specify or delete as appropriate): Pilot course Semester 1: (2011-2012*

Class Contact (via e-learning)	12 lectures available via VC Polycom. *Classes; Thursdays 11.00 - 13.00.* *Week 1 is October 3rd for 10 weeks.*
Workshop / tutorial	4 (x 2-3 hour) practical sessions *Labs Thursdays 14.00-1700 weeks 3,5,7& 9 at NUI Galway.*
Specified Assignment(s)	4 assignments
Autonomous Student Learning	Supplementary lecture material and reading list will be given.

Assessment(s)

MCQ and assignments

	Type	**% of marks**	**Timing**
Test 1	MCQ	0%	Start
Test 2	MCQ	10%	Middle
Test 3	MCQ	10%	End
Total MCQ		**20%**	
Assessment of 4 assignments (20% each)		**80%**	
Result		Pass / Fail	

Graduate Studies Form for Modules attached to Structured PhD and/or Research Masters Programmes	
Title	Scientific Computing using GPUs (Graphics Processor Units)
Credits (ECTS)	5
Module Places	20
Module Code:	PH505
Elective Places	20

Indicative Module Descriptor:

This is an introductory course on GPU computing and it focuses on using the CUDA (Compute Unified Device Architecture) parallel computing architecture. Prior parallel programming experience and knowledge of UNIX/Linux shell is expected.
The syllabus encompasses the following topics:

- Introduction to GPU Computing
- CUDA programming model
- Threads & thread organisation
- Kernels
- Memory model introduction
- Thread scheduling
- Shared memory & tiled algorithms
- Global memory - coalescing
- Precision
- Profiling
- CUDA libraries
- Advanced CUDA features

Indicative Learning Outcomes:
On successful completion of this module, students should be able to:

- Understand how the GPU hardware can be best leveraged to tackle different types of computation.
- Have good working knowledge of the CUDA architecture and programming model.
- Design and implement simple CUDA kernels.
- Carry out basic profiling optimisations to enhance the performance of CUDA code.

Workload: *(specify or delete as appropriate)*

Class Contact (via e-learning)	12 lectures. Material also available on-line
Workshop / tutorial	4 x (2-3hour) practical sessions
Specified Assignment(s)	4 assignments
Autonomous Student Learning	Supplementary lecture material and reading list will be given.

Assessment(s)
Examination ?

	Type	**% of marks**	**Timing**
Test 1	MCQ	0%	Start
Test 2	MCQ	10%	Middle
Test 3	MCQ	10%	End
Total MCQ		**20%**	
4 x assignments (20% each)		**80%**	
Result		Pass / Fail	

Elective Discipline-Specific Modules.

Graduate Studies Form for Modules attached to Structured PhD and/or Research Masters Programmes	
Title	Principles of Optical Design & Image Formation
Credits (ECTS)	5
Module Places	20
Module Code:	PH506
Elective Places	20

Indicative Module Descriptor:

This module covers the fundamentals of optic al design and image formation. The course will provide graduate students using optical systems with an in-depth knowledge of optical design. In particular, the course focuses on:

Basic Concepts of Geometrical Optics
Basic concepts of image formation
Paraxial Optics
Ray Tracing and Ray Aberrations
Wave Aberrations
Chromatic Aberrations
Basic Principles for Aberration Correction
Principles of Optical System Layout
Optimization of Optical Systems
Optimization Examples
Synthesis of new Lens Designs

Indicative Learning Outcomes:

On successful completion of this module, students should be able to:

- Understand basic principles of optical design
- Develop a basic optical design for an research application in lasers and optics
- Evaluate optical designs of commercial optical instrumentation

Workload: *(specify or delete as appropriate)*

Class Contact (via e-learning)	20 lectures. Material also available on-line
Workshop / tutorial	2 sessions
Specified Assignment(s)	2 Assignments are given using ray tracing programme Review of optical design of instrumentations
Autonomous Student Learning	Supplementary lecture material and other text and web references will be given.

Assessment(s)

Examination ?

	Type	**% of marks**	**Timing**
Test 1	MCQ	0%	Start
Test 2	MCQ	20%	Middle
Test 3	MCQ	20%	End
Total MCQ		**40%**	
Assessment of 2 assignments (30% each)		**60%**	
Result		Pass / Fail	

Graduate Studies Form for Modules attached to Structured PhD and/or Research Masters Programmes	
Title	Physics of Aerosols and Particulate Matter
Credits (ECTS)	5
Module Places	20
Module Code:	PH507
Elective Places	20

Indicative Module Descriptor:

This module covers the fundamentals of Aerosol science and the physical measurements of particulate matter in the nanometre, micron and sub millimetre size range.

In particular the course focuses on:

- Brief History.
- Size Distributions of aerosols particles (nm to µm and above).
- Dynamics of aerosols and particulate matter
- Phoretic Effects.
- Electrostatic Effects.
- Optical Properties (including light scattering physics).
- Air Quality and Climate Effects..

Indicative Learning Outcomes:

On successful completion of this module, students should be able to:

- Understand and represent distributions and properties of aerosols and particulate matter.
- Devise the physics of aerosol evolution and dynamics
- Mathematically quantify the essential properties of aerosols and particulate matter.
- Apply different measurement methodologies in measurements of aerosols and particulate matter.

Workload: *(specify or delete as appropriate)*

Class Contact (via e-learning)	18 x 45 minute online lectures
Workshop	2 tutorials
Specified Assignment(s)	6-9 home work assessments Project: Report to be generated by student on application of course concepts in research project.
Autonomous Student Learning	Supplementary lecture material and other text and web references will be given.

Assessment(s)

Assignments Project Report	Type Problem Report	% of marks 30% 70%	Timing Course Report
Assessment will be by assignments & Report	**100%**		
Result	Pass / Fail		

Graduate Studies Form for Modules attached to Structured PhD and/or Research Masters Programmes	
Title	Nanobiomaterials
Credits (ECTS)	5
Module Places	20
Module Code:	CH508
Elective Places	20
Lecturer	Dr. Yury Rochev

Indicative Module Descriptor:

This module covers the fundamentals of nanobiomaterials.

In particular the course focuses on:

- Introduction to biomaterials
- Description of material science considerations for metals, polymers, ceramics and composites.
- Surface considerations, role of coatings and micro- and nano-scale patterning.
- Biomaterials characterisation across different length scales.
- Biocompatibility
- Design and material choice considerations for implant devices. Sterilisation.
- Biomaterials for replacement of skeletal hard tissues.
- Biomaterials for soft tissue and organ replacement.
- Biomaterials for therapeutic or diagnostic applications.
- Nanobiomaterials in drug delivery, biomimetics, & tissue engineering.
- Regulatory issues.

Indicative Learning Outcomes:

On successful completion of this module, students should be able to:

- Understand biological interactions of different materials.
- Explain the importance of nano-scale structures and surfaces on the biological interactions for different materials
- Develop applications of biomaterials with due recognition of the regulatory context.

Workload: *(specify or delete as appropriate)*

Class Contact (via e-learning)	18 lectures (9x 2 hour lectures) Beginning Feb 2nd 2012, videoconferencing Lectures Thursdays 3-5pm for 9 weeks, ends Mar29th, 2012
Workshop	2 tutorials: Monday, April 2nd, NUI Galway
Specified Assignment(s)	3 assessments Project: Report to be generated by student on application of course concepts to his/ her research project.
Autonomous Student Learning	Supplementary lecture material and other text and web references will be given.

Assessment(s)

Three questionnaires: MCQ at start of module – 0%; Quiz 1 at middle of module – 20%; Quiz 2 at end of module – 20% Project assignment / report	Type MCQ Quiz 1 Quiz 2 Report	% of marks 0% 20% 20% 60%	Timing Start Middle End After
Assessment will be by assignments & Report	**100%**		
Result	Pass / Fail		

Appendix 1: Other graduate inter-institutional modules to be targeted in the further development of the Structured PhD within the School of Physics.

Inspire proposed Modules

- Graduate Course in Nanoscience
- Nanoelectronics
- Nanofabrication
- Microsystems
- Photonic Devices
- Photonic Systems
- Photonic Materials
- Molecular and Cellular Biology
- Nanotoxicology
- Nanobiomaterials
- Electronic Structure Theory
- Statistical Mechanics
- Programming concepts
- Nanosynthesis & Self-assembly
- Nanoscale Characterisation
- Optical design & image formation
- Spectroscopy
- Generic and Transferable Skills Modules
- Writing and Presentation
- Information Literacy
- Teaching & Learning
- Project Management
- Outreach
- Entrepreneurship
- PhD Progress Reporting
- Personal Development Plan
- Research Placements

DRHEA Proposed Modules:

Nanooptics & Biophotonics

- Physics of Nanomaterials
- Spectroscopy & Lasers
- Nanomechanics
- Advanced Atomic Force
- Microscopy for Bionanoscience
- Biophysics at the Nanoscale
- Computational Biophysics
- Biomimicry
- Biological Fluid Mechanics at the Micro & Nanoscale
- Advanced Topics in Atomic Physics
- Technical Skills in Experimental Physics
- Labview
- Many Body Theory
- Magnetic Sensors
- Biophysics
- Radiative Transfer and Spectroscopy
- Soft Matter
- Complex Systems
- Nanophotonics
- Advanced Topics Polymers
- Nanoscience
- Higher Performance Computing
- Numerical Methods
- Planetary and Space Science
- Interstellar Medium
- Cosmology
- Fundamentals of Vacuum Technology
- Fundamentals of Industrial Plasmas
- Holography – Techniques & Applications
- Medical Imaging-Macro to Molecular

SUPA Proposed Modules:

- Plasma Physics
- Quarks & Hadron Spectroscopy
- Superheavy Nuclei
- Accelerators
- Nuclear Instrumentation
- Laser Driven Plasma Acceleration
- Nuclear Reaction Theory & Nuclear Forces
- The Nuclear Fuel Cycle
- Gravitational Wave Detection
- Advanced Cosmology
- Astrobiology & the Search for Life
- Advanced Astronomical Techniques
- Photonic Crystals & Plasmonics
- Polymer & Liquid Crystal Displays
- Optical Control
- Quantum Optics
- Quantum Information
- Ultrafast Photonics
- Advanced Statistical Mechanics
- Computational Chemistry
- Quantum Phase Transitions
- Theoretical Nanophysics
- Experimental Nanophysics
- Chaikin & Lubensky, reading course
- The Interacting Electron Problem in Solids
- Quantum Field Theory
- Magnetism
- Response Functions
- Probes of Condensed Matter
- Disordered Systems
- C_{++}/Object Oriented Programming
- Vacuum Technology
- Introductory Data Analysis
- Shell Scripts
- Advanced Data Analysis
- Introduction to Python