ICGEE

International Centre for Graduate Education in Micro- & Nano- Engineering

PROGRAMME DOCUMENT

DATE: 21 JUNE 2011

VERSION: 1.0- RELEASED

Executive Summary

This document describes the ICGEE National Structured PhD Programme in micro- and nano- engineering. The document has been prepared by the ICGEE Programme Committee. ICGEE recognises that each University has its own internal regulations concerning the award of a PhD degree. This Programme Document is designed to complement such internal regulations while at the same time describing the specific features of the ICGEE structured PhD programme.

The ICGEE programme is an inter-university, inter-disciplinary programme created to improve the number and quality of doctoral graduates from participating member institutions. It achieves this by bringing together a consortium involving a number of third level higher education institutions across Ireland along with the Irish engineering professional accreditation body, Engineers Ireland. The ICGEE consortium also involves several international partners. It relies on the combined strengths of the partner institutions and pools the combined scientific and pedagogical expertise into a single education programme that provides a coherent and collaborative curriculum of the highest quality. In doing so, the programme meets the requirements of the Salzburg Principles for Doctoral Education.

The purpose of the programme is to equip a new cadre of world-class engineering doctoral graduates students with the learning and skills needed to not only participate but play a future leadership role in a diverse, globally-engaged Irish engineering workforce within the context of a 21st century innovation driven society. To achieve this, the ICGEE programme ensures that students acquire a grounding of an international standard in the key subjects underpinning their original research area as well as key transferable skills modules in areas such as Technology & Economic Policy and Technology Strategy. The programme has been developed to be flexible and tailored to the specific needs of the participating student. The training requirements for each student and the timing of the student's participation on the taught component will be determined as a joint decision between the student and their supervisor(s).

The ICGEE Programme has at its core the principle that the engineering sector is of fundamental importance and that the quality of engineering education therefore has a direct impact on the ability of Ireland as a nation to compete in the increasingly global competitive environment of this 21st century. Based on this principle the vision for ICGEE is a National and International engineering graduate education centre capable of producing engineering doctoral graduates able to not only participate but play a future leadership role in a diverse, globally-engaged engineering workforce and 21st century innovation society. To achieve this, the centre provides a student-centric doctoral research and education experience with a unique cross-institutional and international flavour and perspective with the ultimate long-term goal of the provision of a sustainable International PhD and International Engineering Programme.

The Learning Outcomes of the ICGEE PHD programme are designed to meet the learning outcomes of a level 9/10 award within the National Qualifications Authority of Ireland framework, which are described in this programme document under seven Programme areas:

1. Fundamental Mathematics, Science and Engineering concepts
2. Research skills and techniques

3. Creativity and Innovation
4. Engineering Practice & Ethics
5. Social and Business Context
6. Effective Communication skills
7. Career management

The ICGEE Programme adheres to the principle that the Degree of Doctor of Philosophy (PhD) is awarded to ICGEE students following successful completion of a programme of supervised research and advanced education and training. The core of the doctorate is a coherent programme of research, which requires that the student successfully completes original doctoral (NQAI Level 10) research amounting to a nominal minimum of 240 ECTS credits, the outcome of which makes an original and substantial contribution to knowledge.

The basic characteristics of the ICGEE programme are as follows:

1. All students are full time
2. Formal curriculum, training and industrial training documented through the use of individual Professional Development Plans (PDPs)
3. Each student takes at least six modules or the equivalence of 30 ECTS credits over the duration of their doctorate programme
4. Students are required to accrue at least 15 ECTS credits from non-specialist or transferable modules and 15 credits from discipline specific (technical) modules
5. Students are encouraged to take generic courses offered in their home institutions and this additional module work will be documented on their PDPs
6. There are no formal prerequisites for modules other than the ICGEE entry requirements. All graduate students are registered into the ICGEE national structured PhD programme, which has a duration of four years.

The timing for each student's participation on the taught modules will be determined by a joint decision between the student and their supervisor(s), however, ICGEE encourages participants to accumulate a majority of the credits before the last year of their four studentship.

The provision of ICGEE courses is based on a common (shared) curriculum between all academic partners, achieved through sharing between participating institutions. The delivery method for courses is both open and flexible and this is achieved with a combination of blended learning, e-learning, open and distant learning, personalised learning or web-based learning. ICGEE provides the infrastructure and technology (Virtual Learning Environment) for module sharing between the sites and the ICGEE e-learning platform is created to minimise the amount of travel required, thus reducing it to planned meetings between the student and lecturer. All participating members and supervisors within the ICGEE programme are encouraged to provide courses to the programme. The ICGEE Programme Committee assesses the suitability of modules for inclusion into the ICGEE curriculum. In addition to the strict requirements for quality and scientific level, modules will have to have been approved by the Academic council or equivalent accreditation body at the home institution Taught Component Workload.

In regard to admission to the ICGEE programme, in addition to institute specific requirements, each candidate who wishes to enrol on the ICGEE National Structured PhD programme is expected to meet a mandatory academic and language entry requirements. Entry is competitive and successful candidates are selected on the basis of their achievement in a number of research related areas. The PhD research topic must fit within the ICGEE key research areas of Micro- and Nano-engineering.

Institutional affiliation is also compulsory for admission to the ICGEE programme. This means all candidates must be linked to one of the Irish academic institutions within the ICGEE consortium. Consortium members are listed on the ICGEE website at www.icgee.ie. Depending on the availability of funds, ICGEE periodically issues calls to invite suitable applicants to apply for sponsorship for PhD positions in one of the affiliated institutions.

In regard to monitoring, ICGEE adheres to the principles of good practice in the organisation of PhD programmes in Irish Higher Education Institutions defined by the Irish Universities Quality Board (IUQB)). ICGEE also recognises that the host institution maintains full responsibility for supervision, examination and awarding of a NQAI level 10 degree to the ICGEE researcher, on successful completion of a PhD examination. The supervision, monitoring and assessment of each student are a collective responsibility of the supervisor(s), the department/school and the institution. At the end of each academic year, the project supervisor is responsible for providing a written report to the ICGEE Graduate Committee, following the recommendation of the host institution's review of the scholar's progress and where appropriate, the end of year supervisor report reflects the contents of the scholar's PDP.

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1 ICGEE Programme Overview

The ICGEE programme is an inter-university, inter-disciplinary programme created to improve the number and quality of doctoral graduates from participating member institutions. It achieves this by bringing together a consortium involving a number of third level higher education institutions across Ireland along with the Irish engineering professional accreditation body, Engineers Ireland. The ICGEE consortium also involves several international partners.

The programme meets the requirements of the Salzburg Principles for Doctoral Education, agreed by European Ministers in 2005[1], for example the first principle is "*A core component of doctoral training is the advancement of knowledge through original research. At the same time it is recognised that doctoral training must increasingly meet the needs of an employment market that is wider than academia.*"

The purpose of the programme is to equip a new cadre of world-class engineering doctoral graduates students with the learning and skills needed to not only participate but play a future leadership role in a diverse, globally-engaged Irish engineering workforce within the context of a 21st century innovation driven society. To achieve this, the ICGEE programme ensures that students acquire a grounding of an international standard in the key subjects underpinning their original research area. This will facilitate them in understanding the engineering science and technology in their specialist research field.

However, future leaders must also be conversant with how to exploit this original knowledge for the benefit of society – to enhance the competitiveness of industry, to promote growth, employment and higher living standards and to improve the quality of life in terms of health and the environment. Therefore, key transferable skills modules in areas such as Technology and Economic Policy, Technology Strategy, Organizing for Innovation and Technology Innovation and Design are also made available to the doctoral students.

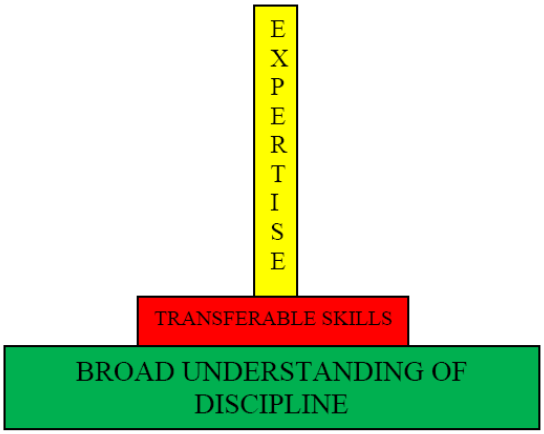


Figure 1 - The inverted T-shaped model for doctoral education

The programme is a structured PhD programme that adopts the so called inverted T-shaped model[2] for doctoral education, illustrated in the Figure. This model is designed to meets the needs of enterprise and industry by ensuring that PhD graduates not only have the very specific **research expertise** expected of a doctoral graduate but also have a **broad knowledge** of their discipline that is critical to the value of PhDs for enterprise and it is an attribute that is very difficult

[1] *http://www.eua.be/eua/jsp/en/upload/Salzburg_Conclusions.1108990538850.pdf*
[2] *The Role of PhDs in the Smart Economy, Forfas Report, December 2009.*

for companies to develop in-house. The model also demands that graduates are equipped with **transferable skills** such as project management, communication, etc.

The current membership of the programme, is made up of the following HEIs;

- Athlone Institute of Technology – AIT.
- Cork Institute of Technology – CIT
- Dublin Institute of Technology – DIT
- Dublin City University - DCU
- National University of Ireland, Galway – NUIG
- Trinity College Dublin – TCD
- University College Cork – UCC
- University College Dublin – UCD
- University of Limerick - UL

Reflecting the increasing collaboration in international level engineering research and education, the ICGEE graduate research education programme (or GREP) also includes participation from Northwestern University, Evanston, IL, USA, the Institute National Polytechnique de Grenoble (INPG), France, Chalmers University of Technology, Sweden, Edinburgh University, UK and Fudan University, Shanghai, China.

The participation of Irish industry has also been priority for the centre and the consortium has received significant encouragement and support during the exploratory phase from two major Irish industry interest groups; MIDAS Ireland (Electronics sector) and MICROMAN (micro-nano technologies manufacturing sector), strongly interested in the shaping of and access to a potentially unique pool of international talent for Irish industry

1.1 Purpose

ICGEE recognises that each University has its own internal regulations concerning the award of a PhD degree. This Programme Document is designed to complement such internal regulations but at the same time adhere to the general principles of a structured PhD programme as defined in the HEA literature. Students and their supervisor(s) will both have access to the skills training material under the ICGEE curriculum.

The ICGEE programme is developed to be flexible and tailored to the specific needs of the participating student. For example, the training requirements for each student and the timing of the student's participation on the taught component will be determined by a joint decision between the student and their supervisor(s) and not prescribed by ICGEE. However, the student/supervisor team must ensure that the appropriate numbers of courses are taken before the end of the student's study period (four years maximum). Furthermore, the student/supervisor team should also recognise that the time spent on structured elements of the programme (lectures, workshops, planning, assessment, reviews etc) should not been seen as "*lost research time*", but ultimately as the "*support time*" spent on research activities.

1.2 Rationale

The Engineering sector is of fundamental importance and central to development and growth in all advanced economies. The quality of engineering education therefore has a direct impact on the ability of

Ireland as a nation to compete in the increasingly global competitive environment of this 21st century. For the past two decades, the expansion in the Irish economy has been underpinned by a strong graduate engineering output at the primary degree level.

However, it is now recognized[3] that to develop a leading 21st century innovation driven economy will require both a significant increase in the output of doctoral level trained engineers coupled with dramatic changes in engineering education. There is a need to prepare engineers to deal with the rapid pace of technological change, the design and manufacture of products often within multi-national, multi-site teams coupled with world-wide supply chains. There is also a need to arm engineers to address the complex technical, social and ethical questions raised by emerging technologies and global trends. The International Centre for Graduate Education in Micro- and Nano- Engineering (ICGEE) represents a significant and concerted response from the Irish government to this challenge.

The fields of Micro and Nano-engineering have reached a high-level of complexity and at the same time undergoing major changes as follows:

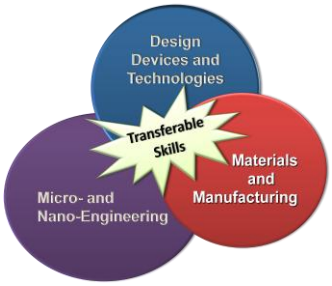
- The "More Moore" era for CMOS in which major challenges are appearing at the level of deep sub-micron technologies, characterization techniques, device physics, device models, circuit design techniques using low-voltage and leaky devices, spread of device parameters, power dissipation, etc.
- The "More than Moore" domain, in which new opportunities are emerging with the capability to combine a wide variety of components in a SoC or SiP and Micro-systems/Nano-systems approach, opening the door to numerous innovative applications in RF, automotive, biomedical and numerous others.
- In the "beyond CMOS" field in which completely new components are being developed from disruptive research, including SET, Nano-wires, and others requiring a need to reinvent circuit and system design techniques.

In view of the increasing multidisciplinary nature and content of these emerging research domains, a broad but in-depth coverage of related problems is required. Furthermore, it is nearly impossible to cover these topics in a traditional Bachelor/Master degree course. For this reason, the ICGEE doctoral training programme has been created to allow graduate students to select a set of advanced courses that fit the needs for their PhD research work. It is further recognized that even the larger and most highly reputed Universities in terms of advanced scientific research cannot provide all courses covering the whole domain of Micro & Nano-engineering within these emerging fields. Therefore, the creation of the ICGEE national structured graduate education programme is derived based on a common (shared) curriculum between all academic partners in which leading academics is their respective fields will provide advanced level modules (discipline specific and Transferable courses) to graduate students from participating members in the programme. This is in recognition that a single institution will not be capable of providing

[3] *Engineering Research in Irish Economic Development, Report of the Irish Academy of Engineering, Dec 2011*

as high of standard programme as compared to the ability to provide an internationally competitive programme through inter-institutional collaborative education for all Irish graduate students.

1.3 Vision and Aim



The vision for ICGEE is a National and International engineering graduate education centre capable of producing a new cadre of world-class engineering doctoral graduates able to not only participate but play a future leadership role in a diverse, globally-engaged engineering workforce and 21st century innovation society. To achieve this, the centre provides a student-centric doctoral research and education experience with a unique cross-institutional and international flavour and perspective.

The aim of the ICGEE PhD curriculum is to educate "the best of the best" postgraduate researchers from a range of disciplines, who wish to pursue inter-disciplinary research in Micro- and Nano-Engineering and acquire valuable transferable skills in commercialization and entrepreneurship. The programme has the key components of an international PhD:

- Transferable professional skills – training with specific modules on Intellectual Asset Management, Technology Strategy, Organising for Innovation, Technology Innovation & IP, etc
- Training in Generic skills which can accelerate the completion time for the doctorate
- Domain specific Specialist technical knowledge from global academic leaders
- World-class research experience

ICGEE Programme scholars receive specialist technical training in the Design, Fabrication & Characterization of Electronic, Photonic and Electro-mechanical Micro- and Nano-Systems. They will also receive training in Innovation, Commercialization and Entrepreneurship skills that will provide the added know-how in becoming future leaders. ICGEE Engineering students graduate having gained an international research experience and a global engineering perspective. A key feature of this is the student's participation in international summer schools, workshops, industry internships and research collaborations within and external to the international ICGEE consortium member networks.

The ultimate long-term goal is the provision of a sustainable International PhD and International Engineering Programme. The participation of Engineers Ireland who are the national engineering accreditation body in Ireland is included to ensure widespread acceptance of future graduate output in the global engineering profession.

1.4 Learning Outcomes

The ICGEE PHD programme is designed to meet the learning outcomes of a level 9/10 award within the National Qualifications Authority of Ireland[4] framework. Graduates of the programme will be able to demonstrate successful achievement of a range of learning outcomes, by building on their previous learning and educational attainment and through their engagement with both the taught modules of the programme and doctoral level research at their host institution. The learning outcomes[5] for this programme are listed below under a number of Programme areas. The areas are intended to be contiguous but it is recognised that occasional overlap is unavoidable. The inclusion of these learning outcomes is not intended to provide assessment criteria for the PhD student; instead, they are presented to give a baseline for the highest expectations standards for an international PhD programme.

Fundamental Mathematics, Science and Engineering concepts

- Knowledge and understanding of the principles, concepts, limitations and range of applicability of established mathematical tools and methods;
- Knowledge and understanding of the theoretical bases and the related assumptions underpinning the engineering sciences relevant to their engineering discipline;
- Knowledge and understanding of a wide range of engineering materials, processes and components;
- Knowledge and understanding of related developing technologies and how they might impinge upon their branch of engineering;

Research skills and techniques

- The ability to recognise and validate problems and to formulate and test hypotheses.
- Integrate knowledge, handle complexity and formulate judgements with incomplete or limited information;
- Create models by deriving appropriate equations and by specifying boundary conditions and underlying assumptions and limitations;
- Identify and use appropriate mathematical methods for application to new and ill-defined engineering problems;
- Identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques;
- Develop software tools including numerical techniques to solve engineering problems
- An ability to summarise, document, report and reflect on progress.

[4] The National Qualifications Authority of Ireland has put in place a ten-level awards framework stretching from primary level education to doctoral level education. The framework specifies the learning outcomes at each level. Further details on the NQAI are available at www.nqai.ie and on the framework at http://www.nqai.ie/FanDiagram/nqai_nfq_08.html

[5] Based on: Accreditation Criteria for Engineering Education Programmes (March 2007) by Engineers Ireland (http://www.engineersireland.ie/media/engineersireland/services/Download%20the%20accreditation%20criteria%20(PDF,%20240kb).pdf)

Creativity and Innovation

- The ability to trace the evolution of understanding of the innovation process and establish developmental links between innovative capacity, performance and profitability;
- Identify, understand and develop the skills necessary to manage innovation at the operational and strategic levels;
- Demonstrate an ability to analyse organisational structures and processes in the light of technology management requirements;
- An awareness of the interdisciplinary and multi-functional nature of the innovation process and of the impact of cultural factors;
- Critically comment on methods of stimulating and promoting technological innovation, of accessing appropriate support and of protecting and benefiting from the investment;
- Demonstrate an ability with the technique of case analysis, formulating possible appropriate courses of action as a member of a group and presenting and defending proposals or idea before peers;
- Recognise ethical and environmental factors and constraints in the implementation of innovation-related proposals

Engineering Practice & Ethics

- Ability to reflect on social and ethical responsibilities linked to the application of their knowledge and judgements;
- Demonstrate awareness of issues relating to the rights of other researchers, of research subjects, and of others who may be affected by the research in society and the need for the highest ethical standard of practice, e.g. confidentiality, ethical issues, attribution, copyright, malpractice, ownership of data and the requirements of the Data Protection Act.
- Demonstrate appreciation of standards of good research practice in their institution and/or discipline.
- Knowledge and understanding of the health, safety and legal issues and responsibilities of engineering practice and the impact of engineering solutions in a societal and environmental context;
- Justify the principles and experimental techniques used in one's own research.
- Understand the process of academic or commercial exploitation of research results.
- Knowledge and understanding of the framework of relevant legal requirements governing engineering activities, including personnel, environmental, health, safety and risk issues.

Social and Business Context

- Recognise and make use of the interactions between the engineering technologies and the technologies associated with other disciplines and professions;
- Ability to consult and work with experts in various fields in the realisation of a product or system;
- Knowledge and understanding of the respective functions of technicians, technologists and engineers and how they together constitute the engineering team;
- Knowledge and understanding of group dynamics and ability to exercise leadership;
- Knowledge and understanding of concepts from a range of areas outside engineering
- Develop and maintain co-operative networks and working relationships with supervisors, colleagues and peers, within the institution and the wider research community at the national and international level.

- Understand one's behaviours and impact on others when working in and contributing to the success of formal and informal teams.
- Be aware of group dynamics; listen, give and receive feedback and respond perceptively to others

Effective Communication skills

- Write clearly and in a style appropriate to purpose in order to create deeper understanding and maximum impact on a given audience;
- Construct coherent arguments and articulate ideas clearly to a range of audiences, formally and informally through a variety of techniques.
- Write technical papers and reports and synthesise one's own work and that of others in abstracts and executive summaries;
- Constructively defend research outcomes at seminars and viva examination.
- Contribute to promoting the public understanding of one's research field and engineering at large.
- Effectively support the learning of others when involved in teaching, mentoring or demonstrating activities.

Career management - to be able to:

- Appreciate the need for and show commitment to continued professional and career development.
- Take ownership for and manage one's career progression, set realistic and achievable career goals (S.M.A.R.T[6].), and identify and develop ways to improve employability.
- Demonstrate an insight into the transferable nature of research skills to other work environments and the range of career opportunities within and outside academia.
- Present one's skills, personal attributes and experiences through effective CVs, applications and interviews.
- Ability to plan and carry through, self-directed Continuing Professional Development to improve one's own knowledge and competence;

[6] *Specific Measurable, Attainable, Realistic and Time bound*

2 ICGEE Programme Structure

2.1 Introduction

The Degree of Doctor of Philosophy (PhD) is awarded following successful completion of a programme of supervised research and advanced education and training. The degree is generally awarded only where the outcome of the research makes an original and substantial contribution to knowledge and where the candidate has demonstrated the capacity to pursue original research. The core of the doctorate will be a coherent programme of research, which requires that the student successfully completes original doctoral (NQAI Level 10) research amounting to a nominal minimum of 240 ECTS credits, the outcome of which makes an original and substantial contribution to knowledge. In accordance with international norms, credit for original doctoral research activity shall only be awarded where the work conducted has been assessed on the basis of a submitted thesis in acceptable form and deemed to be of a satisfactory standard, containing material appropriate for peer-reviewed publication

2.2 Structured PhD Education

The Classical or Apprenticeship Model' of a PhD was of 3 to 4 years duration with students working alone or in very small groups with a single supervisor within their own institution. The PhD thesis was the basis on which the award was made and training in generic and discipline specific skills were seen as 'extras' usually delivered in an ad-hoc fashion. A Structured PhD Programme (or Apprenticeship-Plus Model) incorporates the apprenticeship model and as such recognises that the core element of any PhD is research and generation of knowledge and therefore the thesis remains the basis on which a PhD award is made. The IUQB[7] defines a Structured PhD Programme as "***A graduate programme of study undertaken by PhD students that maintain a research–based education, but one that is augmented by activities that support the acquisition of a range of relevant specialist and generic skills***". The guidelines cover all aspects of the structured PhD programme with sections on the institutional organisation, recruitment admission, induction and communication, supervision and supervisors, the student, the project, professional development, monitoring progress, the dissertation, the examination, the graduation and data records and reporting on PhD programmes. In essence the structured PhD can be described as a '***PhD in which transferable and disciplinary training is an integral part of the education, and which is characterised by a high quality research experience***.' The structured PhD is therefore designed to meet the needs of an employment market that is wider than academia.

Different Universities have just recently started to implement the concept of a Structured PhD in their graduate education programmes. As result, differing models are known to exist within partner institutions and across the member universities. The two examples below are representative of the different models;

[7] *"Good Practice in the organisation of PhD programmes in Irish Higher Education, National Guidelines 2009'*

2.2.1 Programmatic Structured PhD

The programmatic structured PhD degree generally involves the collective training of a cohort of students who enter the programme at the same time and share the common coursework and training over the duration of their PhD. The training is done in parallel to individual research work for each student. Such a programme is more suitable for students located within close proximity of where the taught training will be provided e.g. students from several colleges in the same university or students from different universities located within the same metropolitan area that have a framework in place for inter-university credit transfer of ECTS points. Such a framework is necessary for any inter-university exchange of courses to function.

2.2.2 Individually Specified PhD training

In this model, the taught training is specified on an individual basis for each student. A student and principal supervisor will agree a suitable structured programme of study which is consistent with the HEA/ICGEE definition for a structured PhD. In this case, the specified training will be tailored to the student's background, discipline and project area. This model is more amenable to a national structured PhD programme as in the case of ICGEE in which several Universities from multiple metropolitan regions are participating.

2.3 The ICGEE structured PhD Model

The ICGEE structured PhD model is more closely related to the *Individually Specified PhD training* model described above in that all the students did not join the programme at the same time and are also allowed to tailor their training needs on an individual basis. ICGEE students are hosted in different partner institutions working is different research fields as defined in the ICGEE objective statement. As such, ICGEE recognises that students will have different discipline training requirements and hence a more individually targeted approach to their skill training. It is however expected that each student will receive the same graduate training at their home institution which is broadly in line with the definition agreed by the Deans of Graduate Studies to the HEA in December 2008 and consisting of a high-quality of original research supplemented by formal training in technical and transferable skills and characterised by a formalised approach to personal & professional career development with clear timelines for completion. The goals of the ICGEE structured PhD programme and based on the HEA definition are as follows;

- To provide a high quality research environment leading to the production of an internationally recognised PhD thesis
- To broaden the education at doctoral level through student's taking advanced courses or acquiring a broader range of skills, in or close to their academic discipline
- To accelerate induction into research by provision of training in key generic and disciplinary research skills.
- To enhance the ultimate employability of PhD graduates by provision of career relevant transferable skills
- To provide on-going feedback and monitoring of progress through regular reviews in both research and professional development involving but not solely the student's principal supervisor.

- To enhance the student experience by providing additional support from academic staff, peers, and others, avoiding classical problems such as student isolation and narrow focus of research.

Consistent with HEA definition for structured PhD programmes, the following table presents the basic characteristics of the ICGEE programme

- All students are full time
- Formal curriculum, training and industrial training documented through the use of individual Professional Development Plans (PDPs)
- Each student to take at least six modules or the equivalence of 30 ECTS credits over the duration of their doctorate programme.
- Students will be required to accrue at least 15 ECTS credits from Non- specialist or Transferable modules and 15 credits from discipline specific (Technical) modules.
- Students will be encouraged to take generic courses offered in their home institutions and this additional module work will be documented on their PDPs
- There will be no formal prerequisites for modules other than the ICGEE entry requirements.

The aforementioned framework is applicable to all graduate students registered into the ICGEE national structured PhD programme. The duration for the programme is four years either as a research Masters transferred to PhD status or as a 4 year PhD with set milestones or goals carefully monitored by the host institution throughout the programme.

2.4 Types of Training

The ICGEE Doctoral programme has several distinct features based around the core components of a 21st century international PhD. The total workload for the taught component of this programme will be at least the equivalent of 30 ECTS points. The following section provides more information on the taught training component of the programme.

- ***Discipline Specific skills*** - the multidisciplinary nature and content of today's research domains requires a broad but in-depth coverage of related subjects and topics involved. These courses offer the student the opportunity to develop key discipline-specific training needs required to effectively and efficiently undertake their research work.
- ***Transferable skills training*** - transferable skill are broadly defined as those that do to relate specifically to the student's research field but are designed to develop other particular career relevant skill-sets. Examples include Business, Innovation, Entrepreneurship, teaching and learning, languages etc)
- ***Generic skills training*** - generic competences can be described as broad cross disciplinary research-relevant skills such as technical writing, effective communication, time management and project management, etc. Generic skills can accelerate the time to completion of the research program.
- Summer and winter schools, Fabrication training, seminar series etc

2.5 Module Development and Delivery

A key element of any structured PhD programme is the availability of modules specifically designed for post graduate research student (technical, transferable and generic courses). For reasons of scale, cost and facilities, provision of ICGEE courses is based on a common (shared) curriculum between all academic partners. achieved through sharing between participating institutions. As such, the delivery method for courses wherever possible is both open and flexible

Consequently, ICGEE provides the infrastructure and technology (Virtual Learning Environment or VLE) for module sharing between the sites. Examples of such technologies include e-learning content delivered either synchronously (live) or asynchronously (on-line podcast or video-cast of lectures). It is also recognised that in some cases, some level of student mobility will be required throughout the life cycle of the module. The ICGEE e-learning platform is created to minimise the amount of travel required, thus reducing it to planned meetings between the student and lecturer, e.g. exams, laboratory experiments, presentation of team project, etc).

All participating members and supervisors within the ICGEE programme are encouraged to provide courses to the programme. In fact, the provision of high quality courses by members is seen as critical to the long term sustainability of the programme. The numbers of courses available to ICGEE students in the 2010/2011 academic year are listed in Table 1 and Table 2

One of the key objectives of the ICGEE programme is to provide a shared and delocalised curriculum to support doctoral training in Micro & Nano-Engineering in Ireland. As such, the delivery method for courses wherever possible is both open and flexible. This is achieved with a combination of blended learning, e-learning, open and distant learning, personalised learning or web-based learning. This open and flexible learning environment is one in which most of the teaching is conducted by someone removed in space and time from the learner. Example delivery methods deployed include the following or combinations thereof.

- Live streaming of lectures to students
- A blend of on-line learning material (lectures, notes etc) and periodical interactions between the lecturer and students (tutorials) either face to face or via the web
- Short intensive one week modules or block delivery
- Traditional class room (on-campus) attendance where physical proximity to the classroom is not an issue for the student
- Summer schools and workshops

ICGEE facilitates the deployment or delivery of the shared curriculum through its Virtual Learning Environment or VLE. The VLE platform provides the technology and infrastructure aimed at delivering modules to scholars who are not physically "on site" in a traditional classroom or campus sense thus creating an educational experience of equal quality for the learner that best suits their needs outside the classroom.

2.5.1 Module Acceptance Criteria

The ICGEE Programme Committee assesses the suitability of modules for inclusion into the ICGEE curriculum. In addition to the strict requirements for quality and scientific level, courses will have to have been approved by the Academic council or equivalent accreditation body at the home institution. For courses to be accepted into the ICGEE curriculum, they will have to fulfil the objectives of the ICGEE programme.

The Module selection criteria is therefore be based on the following

- Course syllabus fits within the ICGEE objectives of Micro & Nano-Engineering (Design, Fabrication & Characterization of Electronic, Photonic and Electro-mechanical Micro- and Nano-Systems)
- Courses should be designed to meet the learning outcomes of a level 9/10 award within the National Qualifications Authority of Ireland framework

- Course should be developed for open and flexible learning allowing participation by off-site students – virtual classrooms
- An alternative to virtual classroom courses is that they should be developed for intensive block-delivery (preference of max one week duration)
- Timely announcement of the course containing all course details.
- Quality and scientific level: content, handling and reference to actual state-of-the-art issues, lecturer(s), , lecture notes & resources, infrastructure and organization, etc
- Accessibility to both ICGEE and non-ICGEE students and professionals. Flexible format to address PhD students (Tutorial introductions, hands-on sessions, lectures) and professionals (lectures with reference to industrial needs and issues)
- Course fitting the rules for the proposed number of ECTS credits
- Course accredited by the Doctoral School/Academic council of the home university before the start of the course
- Assessment/Exam/Evaluation organized at the completion of the course and issue of a certificate for ECTS credits

Modules offered by members are submitted to the ICGEE administrator in the form of a Module descriptor using the template provided by ICGEE. In the case of discipline specific courses, the lecturer or Module coordinator will provide a comment on the relevance of the module to the overall ICGEE objective. Following approval by the ICGEE Programme Committee, the module will appear in the ICGEE Calendar (website) on training modules under either heading of Transferable, Generic or disciplinary training modules.

2.6 Taught Component Workload

The total workload for the taught component for each student enrolled into the ICGEE structured PhD programme will be 30 ECTS points accrued over the four years of their PhD programme. Of the total ECTS points, half (15 points) will be accumulated from attending the technical or discipline specific courses and the other half (15 points) from transferable and/or generic courses. The curriculum will offer several courses from each category from which students (and their supervisors) will select from. Courses will be selected. The timing for each student's participation on the taught strand will be determined by a joint decision between the student and their supervisor(s), however, ICGEE will encourage participants to accumulate a majority of the credits before the last year of their studentship (year four).

Table 1 and Table 2 below represent the list of courses offered in the 2010/2011 academic year. A more comprehensive and up to date list of courses for the 2011-2012 academic year is available from the ICGEE website (training Centre) at www.icgee.ie/training/.

Technical Course name/Host University/Lecturer	ECTS points	Lecturer(s)
Reconfigurable System on Chip Design (NUIG)	5	Dr Fearghal Morgan
Integrated Circuit Technology (TCD)	5	Dr Tatiana Perova
Radio Frequency (RF) IC Design (UCC)	5	Dr Kevin McCarthy
Optoelectronics I: Photonics Materials and Devices (DIT)	5	Dr Yuliya Semenova
Optoelectronics II: Devices for Optical Communication (DIT)	5	Dr Yuliya Semenova

Technical Course name/Host University/Lecturer	ECTS points	Lecturer(s)
Nanoelectronics (Tyndall/UCC)	5	Dr Georgios Fagas, Dr Aidan Quinn & Prof Jean-Pierre Collinge
Microsystems Engineering (CIT)	5	Dr Martin Hill
Biomedical Materials (AIT)	5	Dr. Clement L. Higginbotham
Polymer Materials (AIT)	5	Dr. Clement L. Higginbotham

Table 1 - ICGEE technical courses offered in the 2010/2011 academic year

Transferable Course name/Host University/Lecturer	ECTS points	Lecturer(s)
New Business Development (UCD Michael Smurfit Graduate Business School)	5	Dan Maher
Intellectual Asset Management (UCD Michael Smurfit Graduate Business School)	5	Kieran A Comerford
Technology Policy (UCD Michael Smurfit Graduate Business School)	5	Petra Ahrweiler
Organization and Innovation II (UCD Michael Smurfit Graduate Business School)	5	Breffni Tomlim
Productivity Development (UCD Michael Smurfit Graduate Business School)	5	Breffni Tomlim
Product Design and Innovation (UCD Michael Smurfit Graduate Business School)	5	John Cashell

Table 2 - ICGEE Transferable courses offered in the 2010/2011 academic year

3 Admission and Entry Requirements

3.1 Introduction

The ICGEE PhD programme has been created to run in the relevant academic departments of participating Institutions. As such, each PhD candidate is expected to meet the local entry requirements at their intended host institution. In addition to these local requirements, each candidate who wishes to enrol on the ICGEE National Structured PhD programme is expected to meet the following minimum requirements:

3.2 Qualification level

- Mandatory: Honours primary degree with an award at honours grade 2.1 or above, or a qualification deemed equivalent by the ICGEE Admissions Committee
- Desirable: Taught or research masters in a relevant area
- Desirable: Exposure to research and/or relevant publication
- Language: For students whose first language/mother tongue is not English, an IELTS score of minimum 6.0.

3.3 PhD Research Topic

The PhD research topic must fit within the ICGEE key research areas of Micro and Nano engineering which includes topics such as the Design, Fabrication & Characterisation of Electronic, Photonic and Micro or Nano Electro-Mechanical Engineering Systems (MEMs or NEMs)

3.4 Host University Affiliation

Institutional affiliation is compulsory for admission to the ICGEE programme. This means all candidates must be supported by one of the Irish academic institutions within the ICGEE consortium. Consortium members are listed on the ICGEE website at www.icgee.ie.

3.5 ICGEE Scholarships and Application Process

ICGEE may periodically issue calls to invite applicants to apply for PhD sponsorship in one of the ICGEE-affiliated institutions. Specific requirements for each sponsorship call and the application process will be detailed on the ICGEE website at the time of the call.

4 Student Monitoring and Assessment Procedures

4.1 Introduction

This section describes the reporting, monitoring and assessment procedures for ICGEE postgraduate researchers. The Irish Universities Quality Board (IUQB) has published a national guidelines document for Good Practise in the organisation of PhD programmes in Irish Higher Education Institutions (HEI's). The IUQB guidelines describe the roles and responsibilities of all parties involved in the development and administration of Structured PhD programmes[8]. Individual Institutions have subsequently used the IUQB document to develop their own internal processes for assessing and monitoring PhD candidates. This section of the ICGEE programme document is not a substitute for such internal processes. Instead, it relies on such local processes to ensure that the IUQB guidelines are met.

The following subsections describe additional roles and responsibilities related to the monitoring and assessment of ICGEE scholars, specific to the ICGEE structured PhD programme. These include those for the following;

- The Host Institution
- The ICGEE PhD candidate and Supervisor (or doctoral panel)
- The ICGEE Graduate Committee

4.2 ICGEE Specific Roles and Responsibilities

4.2.1 The Host Institution

ICGEE recognises that the host institution maintains full responsibility for supervision, examination and awarding of a NQAI level 10 degree to the ICGEE researcher, on successful completion of a PhD examination. All host institutions affiliated with the ICGEE structured PhD programme have appropriate and established researcher review and progression procedures in place. While there are variations in the procedures in different colleges, the structures, procedures and practises for student assessment and monitoring are broadly in line with the IUQB guidelines for all ICGEE member institutions.

Links to individual institutional research review procedures are included below:

[8] *The Good Practice Guide (No.5), second Edition is published by IUQB in June 2009 and be found at www.iuqb.ie/info/good_practice_guides.aspx*

Institution	Document name & Chapter	Website
University College Cork	Chapter 4, The roles of "Graduate Studies Committees and the operation of progress reviews for research"	www.ucc.ie/en/media/Graduate-Studies-Committees-and-progress-reviews.pdf
Trinity College Dublin	Chapter 2, Section 2.7, Probation, Progress and Continuing Registration on the Research Register	www.tcd.ie/calendar/assets/pdf/calendar-part-2-1011-final-version.pdf
National University of Ireland, Galway	Section 5.8, "Monitoring Progress" in "University Guidelines for Research Degree Programmes	www.nuigalway.ie/graduatestudies/documents/university_research_guidelines.pdf
Cork Institute of Technology	Chapter 9 – Monitoring of Research Progress	www.cit.ie/contentfiles/File/cit_pg_regulations_adopted_may052.pdf?uid=1272460070515
University College Dublin	Sections 19 - Processes for monitor progress throughout the PhD programme	www.ucd.ie/registry/academicsecretariat/academic_regs.pdf
Dublin Institute of Technology	Chapter 2 - Progressing the Research Work	www.dit.ie/media/documents/study/postgraduateresearch/Regulations%205th%20Edition.pdf
Athlone Institute of Technology	Chapter on Meetings in the AIT Graduate School Research and Professional development plan Not found	www.ait.ie/media/athloneit/publications/RPDP---Science-and-Engineering.pdf
Dublin City University	Chapter 6 - Assessment Procedures	www.dcu.ie/info/regulations/postgraduate_regulations_f.shtml
University of Limerick	section 5.11, Progress Reporting & Appendix 6 on Structured PhD Programmes	www2.ul.ie/pdf/388196739.pdf

4.2.2 Primary Project Supervisor Responsibilities

The supervision, monitoring and assessment of each student are the collective responsibility of the supervisor(s), the discipline/department/school and the institution. One of the guidelines for the implementation of Structured PhD programmes calls for supervisory committee or doctoral panels. Every ICGEE scholar should have one principal supervisor who takes full responsibility for the overall management and supervision of the student's work and progress. The responsibilities described below apply to the principal supervisor.

The principal ICGEE student's supervisor is required to submit an annual report to ICGEE, using the provided ICGEE report format/template. The annual supervisor report must be received by September 30th for each academic year and independent of the ICGEE student's start date. The form/template is available on the ICGEE Virtual Learning Environment or VLE at http://icgee.ie/moodle/course/view.php?id=44 (access restricted). An example form is available in Appendix I, section 6.2 below of this programme document.

The submission should include a signed copy of the ICGEE student's latest report (co-signed by the student and principle supervisor) submitted to the institution's Research Review/Assessment Committee (or equivalent), and a summary of the committee's assessment and recommendations..

In summary, the principle project supervisor has the following responsibilities:

- Ensuring that supervisor reports are submitted to ICGEE prior to September 30th each academic year (independent of project start date).
- Advising the ICGEE Graduate Committee (in confidence) in a timely manner, of any circumstances affecting the progress of the ICGEE student's research or formal training programme.
- Advising the ICGEE Graduate Committee in a timely manner, of any changes in circumstances of the primary supervisor which could impact the support of the ICGEE student.
- Drawing up an agreed list of taught modules and credits, to be undertaken by the ICGEE student, in order to achieve the 30 ECTS credit requirement, prior to completion of the PhD programme. Satisfactory completion of the formal training elements is required to guarantee year-on-year funding authorisation.
- Supporting the scholar in developing a Personal Development Plan (PDP), including schedule of academic (taught) and research activities until completion.

Please note that annual funding will be transferred to the funded institution only following receipt by ICGEE of a completed report submission, which confirms the satisfactory progress of the ICGEE S's research, and formal ECTS credit completion.

4.2.3 ICGEE Scholar Responsibilities

All ICGEE students are required to submit two progress reports annually, namely (using the provided ICGEE report format), by the following deadlines (independent of the ICGEE Scholar's start date):

- March 31st
- September 30th,

The ICGEE Scholar report form is also available on the ICGEE VLE website at http://icgee.ie/moodle/course/view.php?id=44. An example form is given in Appendix I, section 6.1 of this programme document. The report should include the following information:

- A summary of the ICGEE Scholar's achievements during the review period
- A plan of activities during the period to the next review.
- A list of all relevant publications accepted or submitted for publication during the review period.
- Proposed publications planned during the period to the next review.
- List of agreed modules and credits completed during the review period
- Agreed list of modules and credits to be completed during the next review period
- Formal confirmation of completed modules, grades and credits.
- Signature of the principal Project supervisor

ICGEE Progamme Committee recommends the following ECTS credit ratio, leading to a total of at least 30 ECTS credits throughout the research programme. Front loading of the taught material reflects the focus on following a taught programme, which includes discipline-specific knowledge to support the original

research activity, and also provides early training in research skills and generic/transferable skills to support personal and professional development.

For ICGEE directly funded Scholars (funded for 4 years)

- Year 1 and 2 combined: minimum of 20 credits
- Year 3: minimum 10 credits
- Year 4: maximum 5 credits

4.2.4 The ICGEE Graduate Committee

The ICGEE Graduate Committee or GC:

- Coordinates the annual assessment of ICGEE students with their host institutions and reviews submitted reports
- Recommends to the ICGEE Executive Committee for year-on-year funding of the ICGEE scholar (up to a maximum of four years), provided that progress is deemed satisfactory by the committee.
- In the event of funding being withheld, an appeals process is available, whereby the ICGEE Scholar may submit an appeal directly to the ICGEE Executive Committee for consideration. The decision of the ICGEE Executive Committee is final.
- Reviews submissions to ICGEE Scholar Calls, compiles a shortlist and recommends candidates for sponsorship (to the ICGEE Executive Committee).
- Supports the development of a Personal Development Plan (PDP) for each ICGEE Scholar, which details the schedule of academic (taught) and research activities to completion of their research programme. The PDP is drawn up by the ICGEE Scholar in consultation with the primary project supervisor, and is expected be a 'live' document which will be subject to continuous review and update during and after subsequent reviews
- Submits an annual summary report on the progress of all ICGEE researchers, to the ICGEE Executive Committee.

5 The ICGEE Curriculum

The following technical modules are available to all ICGEE graduate students and as well are shared with other relevant graduate education programmes. The modules represent the courses offered in the 2010-2011 academic year. A comprehensive and up to date list of courses for the next academic year is available on the ICGEE website at www.icgee.ie/training/. ICGEE modules are accessible to students from all Irish higher education institution (HEIs). Details for each module are described in the module descriptor for that module. The module descriptors for the 2010-2011 academic year are listed in Appendix II of this programme document. Descriptors for an up to list of modules is available from the ICGEE Graduate training website at www.icgee.ie/training/

5.1 Technical

1. Reconfigurable System on Chip Design (NUIG)
2. Integrated Circuit Technology (TCD)
3. Radio Frequency (RF) IC Design (UCC)
4. Optoelectronics I: Photonics Materials and Devices (DIT)
5. Optoelectronics II: Devices for Optical Communication (DIT)
6. Nanoelectronics (Tyndall/UCC)
7. Microsystems Engineering (CIT)
8. Biomedical Materials (AIT)
9. Polymer Materials (AIT)

5.2 Transferable (Business & Innovation)

1. New Business Development
2. Intellectual Asset Management
3. Technology Policy
4. Organization and Innovation II
5. Productivity Development
6. Product Design and Innovation

6 Appendix I: Forms & Templates

6.1 Scholar Interim Report Template

This template is an attempt to standardize the format of these reports and to provide clear guidelines to graduate students as to what it is expected of them in terms of submitting periodic reports to ICGEE. It is acknowledged that the supervisor, as the person with overall responsibility for the research conducted by, and academic progress of, the student provides clear recommendations as to what is required in each instance

ICGEE Student Interim Report Template

TO BE COMPLETED BY THE ICGEE SCHOLAR

Summary Details

Academic year	
Researcher Name	
Researcher Email	
Last Name	
Project Title	
Host Institution	
Project Supervisor(s)	
PhD Start Date	
Target Completion Date	
Number of publications to date	
Report period	(October or March Reports)
Date	

Complete the following questions

Question	Answer	Comment
Have you agreed a Research plan with your supervisor(s)?	YES/NO	
Have you devised a work plan for this plan?	YES/NO	
Are you following this plan?	YES/NO	
How often do you have meetings with your supervisor(s)	Weekly/Bi-monthly/Monthly/Once per term	
Has your work and progress with respect to your project been formally assessed by your supervisor(s)	YES/NO	
Give details of the assessment method(s)	(If different from Host institution's prescribed assessment methods)	
Have you agreed a date with your supervisor for the submission of your thesis	YES/NO	
When do you expect to submit your thesis	State Month and year	
How many lecturing/tutorial/laboratory teaching		

hours per week are you timetabled for		
Are you generally satisfied with your work in the last six months (or reporting period)		
If not, please give details here and/or expand in the section marked "Any other points"		

Research Project Goals

(Goals should be Specific, Measurable, Achievable, Realistic and Time-bound - S.M.A.R.T)

Summary of Publications (completed and planned)

Collaborations (Current and Planned)

Report on Research Completed to Date (last six months)

(Include conferences and workshops attended)

Proposed Work plan and Schedule for Next Six Months

(include planned conference/internships)

Supervisor(s)/Researcher Meetings

Fourth Level Modules Complete/attending to Date

Significant Difficulties Encountered

Any Other Points

6.2 Supervisor Interim Report Template

This document has been prepared as an attempt to standardize the format of supervisor reports sent to ICGEE and to provide clear guidelines to supervisors as to what it is expected of them in terms of their reports on behalf of the ICGEE sponsored students.

ICGEE Student Assessment Form:

TO BE COMPLETED BY THE SCHOLAR'S SUPERVISOR

Summary Details

Academic year	
Researcher Name	
Last Name	
Project Title	
Host Institution	
Supervisor(s) Name	
PhD Start Date	
Target Completion Date	
Number of publications to date	
Assessment period	(October or March Reports)
Date	

Student Assessment

Frequency of meetings with the student			
Weekly	Bi-monthly	Monthly	Once per term

Have you formally assessed the work and progress of the student before completing this report?
Yes or No

Please give details of the assessment method
(you can simply state that the assessment method is in line with that used at the host institution - if it exits)

Is there a serious problem with the research Project

Yes or No

If YES, please give details of the problem:

Area(s) where the researcher may require further training in order to progress

Have you established a date for submission of the thesis

Yes or No, Please state Month and Year

What is the extent of any external/workplace involvement in the project over the last six months or assessment period? (select one of the following;

No Involvement
Passive Support
Resource Input by Industry/External source
Active Involvement

Any further comments?

How Satisfied generally are you with the student's progress. Please select one of the following;

Very Satisfied
Satisfied
Dissatisfied
Very Dissatisfied

Any additional comments on students progress:

Do you consider that the student's work on schedule

Yes or No

If no, please give details

Additional Comments

7 Appendix II - Definitions

The ICGEE programme is managed and administered by the ICGEE programme committee. All submissions from module coordinators relating to the approval of Courses for inclusion in the curriculum will be made to the ICGEE Programme Committee whose chair person will act as the ICGEE programme coordinator. All courses submitted by lecturers for inclusion into the ICGEE curriculum have to be pre-approved by the relevant Programme board (graduate) at the host university and that such programmes meet the learning outcomes for NQAI level 9 and 10. The following sections provide a description of the programme terminology.

7.1 Programme

A programme is an ***approved*** course of study, the successful completion of which normally leads to an award. The award is made when the required number of credits has been successfully accumulated, at appropriate levels, from approved modules, and over an appropriate period, and all other programme requirements have been met.

7.2 Modules

A module is a coherent and self-contained unit of learning, teaching and assessment, which comprises a defined volume of learning activity, expressed in terms of learning outcomes, which are in turn linked to assessment tasks. The volume of educational activity is expressed in hours of student effort and which is linked directly to the credit value of the module. Enrolment is not permitted in a module unless prerequisites, co-requisites and requirements have been satisfied and any other requirements in the module descriptor. The sole purpose of pre-requisites and module requirements is to ensure that students are likely to be capable of achieving the learning outcomes of the module.

7.3 Module Co-ordinator

The Module co-ordinator is the person (or their appointee) responsible for the design, delivery and assessment of the module and acts as the principal examiner for that module. The named lecturer of each course on the ICGEE curriculum is also the module coordinator.

7.4 Module Descriptor

The learning outcomes and curriculum for each module delivered by the Curriculum are formally specified in a module descriptor The module descriptor must specify Module Co-ordinator responsible for the module, the level and credit value of the module, the learning outcomes, indicative curricular content and learning activities, the means by which learning outcomes will be assessed, an indication of expected student workload, any module dependencies (pre-requisites, co-requisites, incompatible modules, exclusions, requirements or recommendations)

7.5 Credits

The European Credit Transfer System (ECTS) provides a framework to clarify the relationship between educational activity and credit value. It was developed to facilitate educational mobility for students and inter-institutional co-operation amongst higher education institutions within the European Union. One ECTS credit corresponds to a norm of 20 to 25 hours of total student effort. Student effort includes all lecture, tutorial, seminar and laboratory contact hours, all work required on assignments and projects, time spent in independent study or research, time spent revising for and completing assessments and any additional time and effort expected of a student enrolled to that module.

Time spent on compulsory professional placements, summer schools or workshops may also be assigned credit, based on criteria reflecting equivalent international standards as recommended by the relevant School and approved by the ICGEE Programme Committee (in consultation with the relevant University Programme Board. All modules must be assigned credits to be awarded after satisfactory completion of the module and successful completion of any associated assessment.

7.6 Module Size

All Graduate taught modules (excluding research and dissertation modules) will be delivered in sizes of 2.5, 5, 7.5, 10 ECTS credits.

7.7 Level

The level of a module is an indication of the level of difficulty of the learning outcomes and the material that will be encountered, and broadly indicates the stage in an academic career when a student is likely to attempt the module. The NQAI level of graduate taught modules is at least level 9

7.8 Stage

A stage defines the transition within a programme whereby a student is expected to progress from one level of the module to the next. Completion of a stage normally requires the accumulation of a threshold of ECTS points or some other assessment method defined in the programme descriptor. Most graduate taught modules in the ICGEE curriculum will normally be completed in one stage.

7.9 Module Dependencies

Module dependencies specify the prior or parallel learning required of students to undertake the module. This leads to the definition of module requirements, pre-requisites and co-requisites. Where there is significant replication of the subject content across different modules there is a need to ensure that students do not gain credit more than once for the same learning outcomes. This leads to the definition of incompatible modules. Most courses offered under the ICGEE curriculum do not have such module dependencies.

7.9.1 Module requirements

If listed, students must have prove of having satisfied a set of requirements, which could include a minimum overall performance at earlier stages of the programme expressed as a required GPA, or a minimum performance at higher, further or secondary education in a specified subject or subjects.

7.9.2 Recommendations

Students are recommended, but not required, to have the prior learning specified in the recommendation; this may include a recommendation to take or have taken certain modules or to have achieved the associated learning outcomes in some other way, or a recommendation expressed in more general terms of the prior learning.

7.9.3 Attendance and Participation

Students are expected to participate in all activities associated with the modules they register to, including regular and punctual attendance at lectures, laboratories and other teaching and learning activities, in accordance with any attendance policy prescribed by the module coordinator.

8 Appendix III - Module descriptors (2010-2011)

Do we have to include the descriptors? Can we simply point the reader to the website instead?

8.1 Technical Module descriptors

8.1.1 Devices for Optical Communications

Module Title:	Optoelectronics I (Devices for Optical Communications)
Module Status:	Available, running in the academic year 2010/2011, starting Sept 2010

Generic Module Information:

Name of module owner/lecturer?	Dr. Yuliya Semenova
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	On-site mode: 1.5 hours lectures per week, 1 hour average laboratory per week Mixed mode: online lectures delivered through the ICGEE VLE combined with 12-hour block on-site laboratory/tutorial activities
Duration of the module:	1 Semester
Assessment methods and weightings where relevant:	End of semester exam (70%) plus laboratory continuous assessment (30%)
Pass standard:	40%
Penalties for late submission of continuous assessment work:	Where work is submitted up to and including 7 days late, 5% of the total marks available is deducted from the mark achieved. Where work is submitted up to and including 14 days late, 10% of the total marks available is deducted from the mark achieved. Work submitted 15 days late or more is assigned a mark of zero.
Number of ECTs or institutional credits assigned to the module:	5 ECTs
Course Content or Syllabus (Optional):	Lasers: • Review of light properties, light-matter interaction, fundamentals of lasers, resonator and beam optics. Semiconductor devices: • p-n junctions, LEDs, lasers, VCSELs , semiconductor optical amplifiers, optical modulators, optical switches, optical detectors. Optoelectronic devices for optical communications: • Optical transmitters and receivers, • Fibre amplifiers: EDFA, PDFA & Raman, • WDM and filters: dielectric, AWG and grating devices, optical switches. • Research directions
Learning Outcomes	On completion of this module, the learner will be able to: • Formulate the operating principles of optoelectronic devices: lasers, light emitting diodes, photo-detectors, optical fibres and waveguides, optical switches and modulators. • Explain through design analysis the key factors affecting the performance of a typical optoelectronic device (e.g. semiconductor laser or detector). • Demonstrate through practical work the correct use of relevant optoelectronics and fibre-optics equipment in obtaining results, analyzing them and relating them to a typical application. • Write a technical report addressing the key issues of a typical applications problem and present conclusions consistent with experimental results. • Undertake a literature search in relation to a specified

	optoelectronics or fibre-optics application and summarize the key issues and findings and include in the report.
Recommended Text	There is no single book recommended for this module. Selected portions of specialized texts are referred to in the lectures. The most relevant text is: • John M. Senior, assisted by M. Yousif Jamro (2009) Optical Fibre Communications: Principles and Practice - Third Edition: Pearson Education Ltd, Essex, England
Supplementary Texts	• J. Singh (1996) Optoelectronics: An Introduction to Materials and Devices, McGraw Hill. • Frederick C. Allard (1989) Fibre Optics Handbook for Engineers and Scientists: McGraw-Hill, New York. • J. Wilson and J. F. B. Hawkes (1989) Optoelectronics, An Introduction - Second Edition: Prentice Hall, Englewood Cliffs, New Jersey 07632.
Other relevant information	

ICGEE Specific Information:

Host Institution and School/Dept:	DIT, School of Electronic and Communications Engineering
Host Institution module code:	OPTO5001
Home institution QA status of module, e.g. "existing module on validated programme"	Existing module on validated NQAI Level 9 programme.
Rationale for including module within the ICGEE programme?	This module introduces a range of topics on the advanced physics and technology of photonic devices used in optical communications and related application areas, making it suitable for ICGEE students undertaking a PhD in Photonics.
Resources required completing course development or aid provision of course?	On-site mode has already been developed so no resources currently needed. Development of the mixed mode may require audio-visual equipment and software, additional resources maybe required for delivery of the block on-site laboratory exercises.
Planned venue?	DIT Kevin St.
Max no. of ICGEE participants?	5
Minimum no. of participants to justify running the course?	Runs with existing programme so no minimum number of participants from ICGEE.
Available to non-ICGEE students	Yes

8.1.2 Photonic Materials and Devices

Module Title:	**Optoelectronics II (Photonic Materials and Devices)**
Module Status:	**Available, running in the academic year 2010/2011, starting Feb 2011**

Generic Module Information:

Name of module owner/lecturer?	Dr. Yuliya Semenova
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	On-site mode: 1.5 hours lectures per week, 1 hour average laboratory per week Mixed mode: online lectures delivered through the ICGEE VLE combined with 12-hour block on-site laboratory/tutorial activities
Duration of the module:	1 Semester
Assessment methods and weightings where relevant:	End of semester exam (70%) plus laboratory continuous assessment (30%)
Pass standard:	40%
Penalties for late submission of continuous assessment work:	Where work is submitted up to and including 7 days late, 5% of the total marks available is deducted from the mark achieved. Where work is submitted up to and including 14 days late, 10% of the total marks available is deducted from the mark achieved. Work submitted 15 days late or more is assigned a mark of zero.
Number of ECTs or institutional credits assigned to the module:	5 ECTs
Course Content or Syllabus (Optional):	Modern optics: • Ray optics, wave optics, electromagnetic optics, polarization and crystal optics, photonic guiding, electro-optics, nonlinear optics and modulators, acousto-optics, optical design, optical properties of thin films. Photonic materials: • Semiconductor physics, polymers and liquid crystals, photonic crystal fibres, materials growth and fabrication. Optical instrumentation and sensors: • optical metrology; interferometry, fundamental length metrology, transfer of the length standard, optical fibres sensors; gyroscopes, hydrophones, strain and temperature sensing, grating & distributed sensors, engineering optical diagnostics; vibrometry and velocimetry, speckle interferometry, displays.
Learning Outcomes	On completion of this module, the learner will be able to: • Formulate the operating principles and demonstrate deep understanding of underlying phenomena of photonic materials and devices: lasers, light emitting diodes, photodetectors, optical fibres and waveguides; liquid crystal displays, optical switches and modulators, photonic crystal fibres, etc. • Specify and select components suitable for implementing a typical fibre-optic or other optoelectronic application (e.g. fibre-optic sensing, image forming system etc.). • Demonstrate through practical work the correct use of relevant photonic equipment in obtaining results, analysing them and relating them to a typical application. • Write a technical report addressing the key issues of a typical applications problem and present conclusions consistent with experimental results. • Undertake a literature search in relation to a specified photonic application and summarise the key issues and findings and include in the report.
Recommended Text	There is no single book recommended for this module. Selected

	portions of specialized texts are referred to in the lectures. The most relevant text is: • B.E.A. Saleh and M.C. Teich (2007) Fundamentals of Photonics: John Wiley and Sons, Inc., New York.
Supplementary Texts	• John M. Senior, assisted by M. Yousif Jamro (2009) Optical Fibre Communications: Principles and Practice - Third Edition: Pearson Education Ltd, Essex, England • J. Singh (1996) Optoelectronics: An Introduction to Materials and Devices, McGraw Hill. • J. Wilson and J. F. B. Hawkes (1989) Optoelectronics, An Introduction - Second Edition: Prentice Hall, Englewood Cliffs, New Jersey 07632.
Other relevant information	

ICGEE Specific Information:

Host Institution and School/Dept:	DIT, School of Electronic and Communications Engineering
Host Institution module code:	OPTO5002
Home institution QA status of module, e.g. "existing module on validated programme"	Existing module on validated NQAI Level 9 programme.
Rationale for including module within the ICGEE programme?	This module introduces a range of topics on the advanced physics and technology of photonic materials, devices and applications, making it suitable for ICGEE students undertaking a PhD in Photonics.
Resources required completing course development or aid provision of course?	On-site mode has already been developed so no resources currently needed. Development of the mixed mode may require audio-visual equipment and software, additional resources maybe required for delivery of the block on-site laboratory exercises.
Planned venue?	DIT Kevin St.
Max no. of ICGEE participants?	5
Minimum no. of participants to justify running the course?	Runs with existing programme so no minimum number of participants from ICGEE.
Available to non-ICGEE students	Yes

8.1.3 Polymer Materials

Module Title:	**Polymer Materials**
Module Status:	**Available**

Generic Module Information:

Name of module owner/lecturer?	Dr. Clement L. Higginbotham
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	Mixed-mode. On-line lectures. Video streaming. On-site laboratory sessions (2 x 3 hours). Assignments.
Duration of the module:	One semester consisting of 12 hours lectures, 30 hours assignments, 6 hours laboratory practicals.
Assessment methods and weightings where relevant:	Continuous assessment (based on assignment submissions)
Pass standard:	40%
Penalties for late submission of continuous assessment work:	Where work is submitted up to and including 7 days late, the maximum mark obtainable is reduced by 10%. Where work is submitted up to and including 14 days late, the maximum mark obtainable is reduced by 20%. Where work is submitted 15 days late or more, the maximum mark obtainable is reduced by 50%.
Number of ECTs or institutional credits assigned to the module:	5 credits
Course Content or Syllabus (Optional):	• Introduction to polymer materials, • Review of polymerisation methods, • Molecular weight determination, • Property modification and the use of additives, • Developments in commodity polymers, • Composites, • Speciality polymers, • Specialised applications, • Diffusion control, Environmental aspects of polymers, • New trends and developments in speciality polymers, • Nanomaterials.
Learning Outcomes	At the end of this module the student will be able to: • Have an enhanced knowledge and understanding of polymeric materials • To know general relationships between structure, properties and applications • Interpret and evaluate the underlying concepts and principles of material selection for advanced polymer applications • Use acquired analytical and characterisation skills at an advanced level to undertake research activities on speciality polymers • Solve technically complex problems relevant to the evaluation of material properties • Communicate information and observations using appropriate terminology through the preparation of written scientific reports • Demonstrate a systematic understanding and critical awareness of new materials and their applications
Recommended Text	"Plastics materials", Brydson, Butterworth-Heinemann, 1999
Supplementary Texts	• "Advanced polymeric materials: Structure property relationships", Shonaike and Advani, CRC, 2003 • "High performance polymers", Johannes Karl Fink, William

	Andrew Publishing, 2008 • "The chemistry of polymers", Nicholson, RSC, 1997 • "Introduction to nanotechnology", Poole and Owens, Wiley, 2003 • "Polymer analysis", Stuart, Wiley, 2002
Other relevant information	The mechanism for registration of ICGEE students with AIT is still to be determined.

ICGEE Specific Information:

Host Institution and School/Dept:	Athlone Institute of Technology – Polymer Engineering Department, Materials Research Institute
Host Institution module code:	PLAS H5001
Home institution QA status of module, e.g. "existing module on validated programme"	Existing module on validated Level 9 degree programme (MSc in Applied Polymer Technology)
Rationale for including module within the ICGEE programme?	'Polymer materials' is a core subject area for a PhD student researching any aspect of polymer science and technology, including at the micro- and nano- scale. This assignment-based module introduces students to polymer materials and focuses on structure/property relationships. It also deals with more specialised advanced polymer systems. The practical element will teach the students to synthesise and characterise a range of polymers using various analytical tools.
Resources required completing course development or aid provision of course?	Will be developed with resources currently available. Access to Moodle for uploading of lectures, videos and assignments (available in AIT). Laboratory space (available in AIT).
Planned venue?	Remote delivery from AIT - Physical delivery at AIT if possible – Practical element on-site at AIT -
Max no. of ICGEE participants?	20
Minimum no. of participants to justify running the course?	1
Available to non-ICGEE students	Yes

8.1.4 Biomedical Materials

Module Title:	**Biomedical Materials**
Module Status:	**Available**

Generic Module Information:

Name of module owner/lecturer?	Dr. Clement L. Higginbotham
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	Mixed-mode. On-line lectures. Video streaming. On-site laboratory sessions (2 x 3 hours). Assignments.
Duration of the module:	One semester consisting of 12 hours lectures, 30 hours assignments, 6 hours laboratory practicals
Assessment methods and weightings where relevant:	Continuous assessment (based on assignment submissions)
Pass standard:	40%
Penalties for late submission of continuous assessment work:	Where work is submitted up to and including 7 days late, the maximum mark obtainable is reduced by 10%. Where work is submitted up to and including 14 days late, the maximum mark obtainable is reduced by 20%. Where work is submitted 15 days late or more, the maximum mark obtainable is reduced by 50%.
Number of ECTs or institutional credits assigned to the module:	5 credits
Course Content or Syllabus (Optional):	• Introduction to biomaterials, • Biomaterials surfaces, • Protein-surface interactions, • Cell-surface interactions, • Surface modification, • Surface characterisation, • Biomaterials for biosensors and diagnostic devices, • Biomaterials for drug delivery, • Biomaterials for organ replacement, • Biomaterials for tissue engineering, • Nano-biomaterials.
Learning Outcomes	At the end of this module the student will be able to: • Interpret and evaluate the underlying concepts and principles of material selection for biomedical applications • Know how a material performs in a certain biological environment • Use acquired analytical and characterisation skills at an advanced level to undertake research activities on biomedical materials • Select the appropriate surface modification method for a particular biomedical material application • Solve technically complex problems relevant to the evaluation of biomedical materials • Communicate information and observations using appropriate terminology through the preparation of written scientific reports. • Demonstrate a systematic understanding and critical awareness of new biomedical materials and their applications • To know general relationships between structures, properties and their relationships
Recommended Text	"Biomaterials Science: An Introduction to Materials in Medicine", Ratner, Academic Press, 2004

Supplementary Texts	• "Biological Performance of Materials: Fundamentals of Biocompatibility", Black, CRC, 2005 • "Service characteristics of biomedical materials and implants", Batchelor and Chandrasekaran, Imperial College Press, 2004 • "Biomedical Nanostructures", Gonsalves, Halberstadt, Laurencin and Nair, Wiley, 2007 • "Biomaterials", Wong and Bronzino, CRC, 2007
Other relevant information	The mechanism for registration of ICGEE students with AIT is still to be determined.

ICGEE Specific Information:

Host Institution and School/Dept:	Athlone Institute of Technology – Polymer Engineering Department, Materials Research Institute
Host Institution module code:	BMED H5001
Home institution QA status of module, e.g. "existing module on validated programme"	Existing module on validated Level 9 degree programme (MSc in Applied Polymer Technology)
Rationale for including module within the ICGEE programme?	The study of biomedical materials is essential for ICGEE students who are undertaking a PhD in any aspect of nanomedicine or nanotechnology as applied to biomedical systems. This assignment-based module introduces students to biomaterial surfaces, biomaterial-cell interaction, biocompatibility, biomaterial characterisation, biomaterials for biosensors and diagnostic devices, biomaterials for drug delivery and biomaterials for tissue engineering. Emphasis will be placed on biomaterials at the nano-scale as the application of materials to biological systems shows interesting characteristics at this level.
Resources required completing course development or aid provision of course?	Already developed so no resources currently needed for the development. Access to Moodle for uploading of lectures, videos and assignments (available in AIT). Laboratory space (available in AIT).
Planned venue?	Remote delivery from AIT - Physical delivery at AIT if possible – Practical element on-site at AIT -
Max no. of ICGEE participants?	20
Minimum no. of participants to justify running the course?	1
Available to non-ICGEE students	Yes

8.1.5 Reconfigurable System on Chip (rSoC)

Module Title:	**Reconfigurable System on Chip (rSoC) Design**
Module Status:	**Available, to be delivered during first semester of 2010-11 academic year**

Generic Module Information:

Name of module owner/lecturer?	Dr Fearghal Morgan
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	Mixed mode. Video streaming Assignment-based (CA) with remote laboratory access 4-6 one-hour remote web link sessions to support assignment work.
Duration of the module:	6 hours video presentations 40 hours assignments 4-6 hours of web-based interaction
Assessment methods and weightings where relevant:	Continuous assessment, pop quizzes, final oral examination (based on assignment submissions)
Pass Standard:	40%
Penalties for late submission of continuous assessment work:	Where work is submitted up to and including 7 days late, 10% of the total marks available shall be deducted from the mark achieved. Where work is submitted up to and including 14 days late, 20% of the total marks available shall be deducted from the mark achieved. Work submitted 15 days late or more shall be assigned a mark of zero.
Number of ECTs or institutional credits assigned to the module:	5 ECTS
Course Content or Syllabus (Optional):	• Reconfigurable technologies and architectures • The digital SoC design and development process • Digital design and analysis techniques • Structured documentation methodology • HDL design capture • Verification strategies (testbenches and bus functional models) • Logic Synthesis • Electronic Design Automation (EDA) tools • Real-world considerations • Use of embedded processors and IP cores. • Related EDA tool-suites • Digital systems design and rSoC case studies • Recent developments
Learning Outcomes	At the end of this module the student will be able to: • Apply steps from specification to implementation of a modular, complex digital embedded reconfigurable hardware (Field Programmable Gate Array, FPGA) system. • Implemented hardware designs on a remote reconfigurable computing hardware laboratory system • Perform structured digital systems design • The assignment-based module progresses from design to implementation of a • Review and prepare formal design and verification documentation • Capture design using an industry standard hardware description programming language (VHDL) and Computer Aided Design tools • Simulate, synthesise, implement a Field Programmable Gate Array (FPGA) hardware proto-type, test hardware design • Participate effectively within a distributed team
Pre-requisites	Some Digital Systems Design knowledge, Programming skills
Recommended Text	Circuit Design & Simulation with VHDL, V.E. Pedroni, 2nd Ed.

Supplementary Texts	Digital Design, Richard E. Haskell & Darrin M. Hanna
Other relevant information	Has been successfully run several times (on-site and remotely) with strong student feedback. Dr Morgan has been awarded the National University of Ireland, Galway President's Award for Excellence in Teaching, 2009. Course Part1 material is available online at www.appliedVHDL.com. Part 2 material is provided to students directly by email.

ICGEE Specific Information

Host Institution and School/Dept:	National University of Ireland, Galway (NUI Galway) Electrical & Electronic Engineering, College of Engineering & Informatics.
Host Institution module code:	EE590 [Takes material mostly from EE427 Digital systems Design & VHDL, 3 ECTS credit module, as well as some from EE316 Digital Systems Design, 3 credit module]
Home institution QA status of module, e.g. "existing module on validated programme"	Existing module on validated NQAI Level 9 degree programmes (Electrical & Electronic Engineering BN121, Electronic & Computer Engineering BP121).
Rationale for including module within the ICGEE programme?	Micro and nano systems commonly interface to digital devices. This module provides participants with extensive hand-on experience of design, documentation, capture, simulation, implementation and proto-typing of digital integrated circuits. The techniques and tools applied in this course can be applied across many areas of microelectronics systems design, microprocessor architecture design, and embedded systems design. The assignment-based module progresses from design to implementation of a modular, complex digital system, implemented on a remote reconfigurable computing hardware laboratory system (Field Programmable Gate Array, FPGA). The course follows a structured design and documentation method, introduces related Electronic Design Automation tools for Hardware Description Language (VHDL) design capture, simulation, logic synthesis and FPGA implementation.
Resources required completing course development or aid provision of course?	Access to remote web link to allow voice, video, text, screen sharing to/from a group of participants.
Planned venue?	Remote delivery from NUI Galway
Max no. of ICGEE participants?	20
Minimum no. of participants to justify running the course?	n/a
Available to non-ICGEE participants?	Yes

8.1.6 Nanoelectronics

Module Title:	**Nanoelectronics**
Module Status:	**Available, to be delivered second term 2010-11**

Generic Module Information:

Name of module owner/lecturer?	Giorgos Fagas (module coordinator)
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	On- site, with remote video conference and live web streaming (ie can view at desk with a web browser).
Duration of the module:	16 lectures. 90 minutes each.
Assessment methods and weightings where relevant:	Continuous assessment and final exam.
Pass standard:	40%
Penalties for late submission of continuous assessment work:	Where work is submitted up to and including 7 days late, 10% of the total marks available shall be deducted from the mark achieved. Where work is submitted up to and including 14 days late, 20% of the total marks available shall be deducted from the mark achieved. Work submitted 15 days late or more shall be assigned a mark of zero.
Number of ECTs or institutional credits assigned to the module:	5 ECTs
Course Content or Syllabus (Optional):	• From microelectronics to Nanoelectronics, challenges and objectives and overview/examples of measured effects; Primary quantum mechanics; Top-down nanofabrication:CMOS scaling, multi-gate transistors, junctionless transistors; • Electronic structure of confined systems: appplication to nanoscale structures (e.g. Si nanowires, graphene, nanotubes); • Bottom-up synthesis, directed assembly and electrical contacting of nanoscale building blocks:nanowires, nanotubes, graphene, nanocrystals; • Quantum transport: elementary theory and effects (e.g. conductance quantisation and fluctuations, coherent and single-electron tunnelling); • Principles of nanoelectronic devices (e.g. multigate FET, Junctionless FET, SET); • Device operation and performance (benchmarking bottom-up vs top-down)
Learning Outcomes	On successful completion of this module, students should be able to: • Illustrate key electronic structure and quantum transport properties of low-dimensional systems using analytical methods and basic numerical computations (e.g. in MATLAB). • Analyse the operating principles of nanoscale electronic devices and interpret measured device data, with particular reference to novel non-planar silicon devices (multi-gate transistors, junctionless transistors), nanowire devices, graphene devices, molecular electronic devices. • Compare and contrast candidate device performance based on fundamental limitations and their (ultimate) potential for high-volume manufacturing. • Recognise the near- and medium-term scaling challenges associated with continued miniaturisation in conventional "top-down" semiconductor technology at and below the

	22nm node. • Summarise the benefits and challenges associated with bottom-up fabrication of nanostructures for future applications in electronics.
Recommended Text (to be confirmed)	• Fundamentals of Nanoelectronics by George W. Hanson (Prentice Hall, international edition 2007) • Introduction to Nanoscience by Stuart Lindsay (Oxford University Press, 2009)
Supplementary Texts	• The Physics of Low-dimensional Semiconductors: An Introduction **by** J. H. Davies **(Cambridge University Press,1997)** • Quantum Nanoelectronics: An Introduction to Electronic Nanotechnology and Quantum Computing **by Edward L. Wolf (Wiley-VCH, 2009)**
Other relevant information	Has been run once very successfully. Good student feedback. Web delivery needs improvement.

ICGEE Specific Information:

Host Institution and School/Dept:	Tyndall National Institute, UCC
Host Institution module code:	UE6005
Home institution QA status of module, e.g. "existing module on validated programme"	Existing module on validated programme. Specifically developed for grad students.
Rationale for including module within the ICGEE programme?	Nanoelectronics is core subject area and ties directly to fabrication training.
Resources required completing course development or aid provision of course?	We need to re-record the lectures with better production standards and to have post editing of the recorded lectures to make them suitable for web archiving.
Planned venue?	Tyndall+ remote delivery.
Max no. of ICGEE participants?	On-site 14, video conference: depends on partner facilities. Remote web: unlimited.
Minimum no. of participants to justify running the course?	8 on site.
Available to non-ICGEE students	Yes

8.1.7 Radio Frequency Integrated Circuit Design (RFIC)

Module Title:	**Radio Frequency Integrated Circuit Design**
Module Status:	**Currently being delivered to UCC students in the 2010/11 academic year**

Generic Module Information:

Name of module owner/lecturer?	Dr. Kevin McCarthy
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	Currently being delivered as 36 1-hour lectures at UCC. Material on web for web delivery. Currently recording voice overs to facilitate improved web delivery.
Duration of the module:	36 hours of lectures. CAD-based assignment.
Assessment methods and weightings where relevant:	End of year 3-hour exam accounting for 80% of marks. Design or analysis assignment accounting for 20% of marks.
Pass standard:	40%
Penalties for late submission of continuous assessment work:	Where work is submitted up to and including 7 days late, 10% of the total marks available shall be deducted from the mark achieved. Where work is submitted up to and including 14 days late, 20% of the total marks available shall be deducted from the mark achieved. Work submitted 15 days late or more shall be assigned a mark of zero.
Number of ECTs or institutional credits assigned to the module:	5 ECTS
Course Content or Syllabus (Optional):	• Building blocks of Radio Frequency (RF) transceivers for mobile telephone and wireless networks; • Review of RF Transistors; • Two-port Parameters for RF Devices; • Common RF terminology including Intermodulation and Noise; • LNA Design using the Smith Chart; • RF Oscillators and Frequency Synthesizers; • RF Mixers and Modulators
Learning Outcomes	At the end of this module the student will be able to: • Determine the 2-port parameters for RF transistors using small-signal equivalent circuit analysis and vice-versa. • Use the Smith Chart to illustrate important RF characteristics such as matching, gain and noise performance. • Design RF Low Noise Amplifiers using Smith Chart techniques for optimum gain and noise performance. • Partition an RF system into functional sub-blocks and describe the trade-offs between the different options for this partitioning. • Determine the characteristics of an RF system such as noise figure, gain compression and inter-modulation. • Analyse and Design Basic RF Oscillators. • Analyse and Design Basic RF Mixers. • Analyse and Design Basic RF Phase Locked Loops and Frequency Synthesizers. • Design, simulate (using a standard simulator as recommended in class), and compose a written performance report pertaining to an RF element chosen from the following list: RF Amplifier, RF Oscillator, RF Mixer, RF Filter, RF Frequency Synthesizer or RF System-on-Chip.
Recommended Text	"RF Microelectronics", Behzad Razavi, Prentice Hall, 1997

Supplementary Texts	• "Design of Analog CMOS Integrated Circuits", Behzad Razavi, McGraw Hill, 2000. • "The Design of CMOS Radio-Frequency Integrated Circuits", Thomas. H. Lee, Cambridge University Press, 2nd Edition, 2003 • "VLSI for Wireless Communication", Bosco Leung, Prentice Hall, 2002 • "RF Circuit design", Christopher Bowick with John Blyler and Cheryl Ajluni, Newnes/Elsevier, 2008 • "Radio-Frequency Integrated Circuits and Technologies", Frank Ellinger, Springer, 2007
Other relevant information	The mechanism for registration of ICGEE students for the written examination at UCC and awarding of credits from UCC is still to be determined.

ICGEE Specific Information:

Host Institution and School/Dept:	University College Cork
Host Institution module code:	EE4011
Home institution QA status of module, e.g. "existing module on validated programme"	Existing module on validated NQAI level 8 degree program (BE. Elec. CK605) where it is an optional final-year module. It is also offered as an option on a taught M.Eng.Sc (Microelectronic Design) course at UCC.
Rationale for including module within the ICGEE programme?	A major application of modern integrated circuit technology is in wireless communications. This module introduces the building blocks of radio frequency ICs for wireless communications and therefore provides a perspective on one of the largest uses for IC technology.
Resources required completing course development or aid provision of course?	Development of voice-overs for existing Powerpoint files and CAD assignment that are suitable for running at remote sites with standard software available.
Planned venue?	Physical delivery at UCC. Lectures being reformatted for web delivery with suitable voice-overs and computer files.
Max no. of ICGEE participants?	10
Minimum no. of participants to justify running the course?	1, on condition the module runs for UCC EE students in the given academic year.
Available to non-ICGEE students	Yes subject to a combined limit of 10 students

8.1.8 Microsystems Engineering

Module Title:	**Microsystems Engineering**
Module Status:	**Currently approved by CIT for full-time delivery – Plan for course to be available in Jan. 2011.**

Generic Module Information:

Name of module owner/lecturer?	Martin Hill
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	Currently full-time. Plan to collaborate with Tyndall to have a combination of online content delivery and practical work experience. (2 hours per week plus ½ on-site training workshops of ½ days)
Duration of the module:	One semester
Assessment methods and weightings where relevant:	End of Semester Exam – 50% Written report – 20% Practical assessment – 30%
Pass standard:	40%
Penalties for late submission of continuous assessment work:	Will be advised during course kick-off lecture.
Number of ECTs or institutional credits assigned to the module:	5 ECTs
Course Content or Syllabus (Optional):	**Introduction to Microsystems** • Description of the design, fabrication and application of microsystems. The current and emerging business markets for microsystem technology. **Component Specification and Design** • System level specification of suitable components and technologies for real-world applications. Layout of ICs and MEMS components. **Modelling and Design** • Electrical, thermal and mechanical modelling and design of microtechnology components and sensors. Combined sensor and interface modelling. **Fabrication** • IC fabrication processes and industry. Microsystems fabrication options. Integration issues. **Microsystem testing** • Characterisation of MEMS system performance using FEM modelling combined with electrical, optical and thermal test equipment. **Case Studies** • Perform case studies in microelectromechanical systems engineering. Describe, model and characterise components with a comparison of system level specifications with modelled and measured performance.
Learning Outcomes	On successful completion of this module the learner will be able to • Describe the emerging microsystems and embedded smart systems industries, the products they are beginning to bring to the market, how these products can be used in existing business and industry and the new businesses and industries springing up based on these products. • Realise integrated microsystem components by

	generating CAD layout files and relating those files to the fabrication process flow. • Evaluate process and design options for integration of microsystem components. • Identify packaging and interconnect options suitable for microsystems applications. • Derive component and system level specifications from the application description and develop application driven integrated microsystem designs.
Recommended Text	None
Supplementary Texts	• Julian W. Gardner, Vijay K. Varadan, Osama O. Awadelkarim 2001, *Microsensors, MEMS, and Smart Devices*, John Wiley and Sons [ISBN: 047186109X] • Elena Gaura, Robert Newman 2006, *Smart MEMS and Sensors Systems*, Imperial College Press [ISBN: 1860944930] • Marc J. Madou 2002, *Fundamentals of Microfabrication*, 2nd. Ed., CRC Press [ISBN: 0849308267] • Mohamed Gad-el-Hak 2006, *MEMS Applications*, CRC Press [ISBN: 0849391393] • Tai-Ran Hsu 2004, *MEMS Packaging*, IET [ISBN: 0863413358] • Sergey Edward Lyshevski 2002, *MEMS and NEMS, Systems Devices and Structures*, CRC Press [ISBN: 0849312620]
Other relevant information	

ICGEE Specific Information:

Host Institution and School/Dept:	CIT, Dept. of Electronic Engineering
Host Institution module code:	INTR8012
Home institution QA status of module, e.g. "existing module on validated programme"	Currently approved for full-time. May need re-approval for online and collaborative delivery.
Rationale for including module within the ICGEE programme?	This course will introduce students to the interdisciplinary skills required to design and apply microsystems, will examine some current commercial microsystems application and will consider future possibilities for the technology. It can be taken by students from different technical backgrounds and introduces a technology which is predicted to find applications in many technical domains.
Resources required to complete course development or aid provision of course?	Will need to make content available online and arrange facilities for workshop(s).
Planned venue?	CIT/Tyndall.
Max no. of ICGEE participants?	Maximum 10 participants total for workshop management.
Minimum no. of participants to justify running the course?	Not decided
Available to non-ICGEE students	Yes

8.1.9 Integrated Circuit Technology (ICT)

Module Title:	**Integrated Circuit Technology (ICT)**
Module Status:	**Available, running in the academic year 2010/2011, starting Sept-Nov 2010 (alternatively Jan-Mar or Jun-Aug 2011)**

Generic Module Information:

Name of module owner/lecturer?	Dr. Tatiana Perova
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	On-site 1.5 hours lectures per week, 1 hour average laboratory per week
Duration of the module:	1 Semester
Assessment methods and weightings where relevant:	End of semester exam (70%) plus laboratory continuous assessment (30%)
Pass standard:	Demonstration good activities during the demonstration section and experimental work and if mark for the report is exceeded 40%.
Penalties for late submission of continuous assessment work:	Penalties for late submission of continuous assessment work: reduction of the overall mark
Number of ECTs or institutional credits assigned to the module:	5 ECTs
Course Content or Syllabus (Optional):	• Processing techniques: The following techniques will be examined in some detail: crystal growth; diffusion; ion-implantation; oxidation; lithography; metallisation; plasma etching. • Spectroscopy: Brief introductory material on application of Fourier Transform Infrared (FTIR) and Raman spectroscopy to IC technology will be presented. • Devices/Circuits: Techniques for fabrication of the following devices, using the processing techniques described above, will be studied: • Bipolar: discrete transistor; monolithic IC transistor; resistor; diode; capacitor; circuit layout for ECL NOR gate. MOS: PMOS, NMOS and CMOS technologies will be introduced and the problem of latch-up will be discussed. • Silicon-on-Insulator will be proposed as an alternative to bulk silicon.
Learning Outcomes	On successful completion of this module the learner will be able to: - • The course provides the students with an opportunity to fabricate a simple PMOS integrated circuit in Microelectronic Technology Laboratory. • The device contains transistors, a resistor, a capacitor and two logic devices. • During the laboratory course the participants will acquire and appreciation of the various stages in the fabrication of the device. • This will include wafer cleaning, field oxidation, the photolithography process, window etching, diffusion, gate oxidation and metallization. • The participants are also fully trained in the safe handling of chemicals. The final part of the course consists of a lecture on device testing and packaging in the lab.

Recommended Text	• S.M. Sze, Semiconductor Devices; Physics and Technology, John Willey & Sons, Inc., USA, 2002 (or any later edition) • J.D. Plummer, M.D. Deal, and P. B. Griffin, Silicon VLSI Technology, Prentice Hall, NY, 2000 (or any later edition). • B.G. Streetman, S. K. Banerjee, Solid State Electronic Devices, Pearson, Prentice Hall, New Jersey, 2000 (or any later edition).
Supplementary Texts	Hand outs and Power Point Presentation will be provided at the site.
Other relevant information	Has been run successfully for at least 13 years. The demonstrations part (6, and 16 hours) has been run successfully for a number of years to students from different colleges and to industry. Good student feedback. Web delivery needs improvement.

ICGEE Specific Information:

Host Institution and School/Dept:	TCD, Department of Electronic and Electrical Engineering
Host Institution module code:	4C6
Home institution QA status of module, e.g. "existing module on validated programme"	Existing module on validated programme, developed for final year students
Rationale for including module within the ICGEE programme?	The object of this course is to provide the student with an opportunity to fabricate a simple MOS integrated circuit and to learn about electrical and optical characterizations.
Resources required to complete course development or aid provision of course?	Already developed so no resources currently needed for the development. However, resources will be required to cover the laboratory demonstrations and the running cost.
Planned venue?	TCD, SNIAM building, 3rd floor, Clean Room
Max no. of ICGEE participants?	10 (at the same time)
Minimum no. of participants to justify running the course?	4
Available to non-ICGEE students	Yes

8.2 Transferable Module descriptors

8.2.1 New Business Development Module Descriptor

Module Title:	**New Business Development**
Module Status:	**M.Sc in Technology Management**

Generic Module Information

Name of module owner/lecturer?	Dan Maher
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	In class with either 12 x 2 hr modules or 6 x 4hr modules.
Duration of the module:	Normally over a full semester (15 week) period.
Assessment methods and weightings where relevant:	Continual assessment based on case presentations and participation will account for 40% of the total marks. The remaining 60% linked to a final exam
Pass standard:	40%
Penalties for late submission of continuous assessment work:	20% of mark assigned to submission– one day late 40% of mark assigned to submission – more than one day.
Number of ECTs or institutional credits assigned to the module:	5
Course Content or Syllabus (Optional):	The course will be lecture and discussion based and will draw, on occasion, on visiting speakers. The primary learning however will focus on the key reading materials and participants will present assigned cases and lead class discussion on a range of core topics.
Learning Outcomes	Objectives : An understanding of - • The Screening of New Venture Opportunities • The Dynamics of Product Innovation and the Product Planet Model • The Marketing strategies of New High-Technolgy Products • The Entrepreneurial Team • The Resource requirements for New Ventures • How to Craft the Business Plan • Entrepreneurial Finance & Venture Funding • The Venture Deal : Structure & Valuation • The Exit Strategy.
Recommended Text	New Venture Creation – Entrepreneurship for the 21st Century Authors: Jeffry Timmons & Stephen Spinelli Publisher: McGraw Hill 8th Edition ISBN 879-007-127632-0
Supplementary Texts	The ART of the START Author : Guy Kawasaki Publisher: Portfolio/Penguin ISBN 1-59184-056-2 Crossing the Chasm Author : Geoffrey Moore Publisher Harper Business RECOMMENDED Raising Venture Capital for the Serious Entrepreneur Author : Dermot Berkery Publisher: McGraw Hill ISBN 13 : 978-0-07-149602-5
Other relevant information	

ICGEE Specific Information

Host Institution and School/Dept:	UCD NITM
Host Institution module code:	BMGT 41010
Home institution QA status of module, e.g. "	Standard M.Sc. in Technology Management Module
Rationale for including module within the ICGEE programme?	To give and understanding of how research can be converted to business
Resources required completing course development or aid provision of course?	Text books, Internet Access, Time - Attendance at Class and Group work preparation.
Planned venue?	Graduate School of Business UCD
Max no. of ICGEE participants?	25
Minimum no. of participants to justify running the course?	15
Available to non-ICGEE students	Yes

8.2.2 Intellectual Asset Management Module Descriptor

Module Title:	**Intellectual Asset Management**
Module Status:	**Currently delivered in UCD for the MSc in Technology Management**

Generic Module Information

Name of module owner/lecturer?	Kieran Comerford
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	12 two hour lectures, two hours per week on site.
Duration of the module:	24 hours over 1 semester
Assessment methods and weightings where relevant:	Exam 70%, assignment and class participation 30%
Pass standard:	40
Penalties for late submission of continuous assessment work:	Deduct 10% per week
Number of ECTs or institutional credits assigned to the module:	5
Course Content or Syllabus (Optional):	• Innovation theory, • Technology Acquisition Strategies, • Sourcing Technologies, • Technology Assessment and Valuation, • Intellectual Assets and • Intellectual Property, • Legal aspects of technology management, • Licensing and Technology Transfer, • Innovation environment.
Learning Outcomes	On completion of this module students should be able to: • Understand the role of technology as a resource and how to use technology strategically in a business, • To understand, identify and be able to exploit intellectual assets, to know how to acquire technology internally and externally assess technology sources and strengths using modern information systems, to take decisions on how technology is protected and licensed, to handle legal contractual and commercial issues.
Recommended Text	Managing Technology and Intellectual Assets, Kieran Comerford, CTM Books 2003
Supplementary Texts	Winning at New Products R. G Cooper, Perseus, 2001
Other relevant information	

ICGEE Specific Information

Host Institution and School/Dept:	UCD Smurfit School/Business
Host Institution module code:	BMGT40990
Home institution QA status of module, e.g. "	Existing module on validated programme
Rationale for including module within the ICGEE programme?	Relevant to research students
Resources required completing course development or aid provision of course?	Complete
Planned venue?	UCD Smurfit School
Max no. of ICGEE participants?	10
Minimum no. of participants to justify running the course?	Already running next semester

Available to non-ICGEE students	yes

8.2.3 Development Productivity Management Module Descriptor

Module Title:	**Development Productivity Management**
Module Status:	**Currently delivered in UCD for the MSc in Technology Management**

Generic Module Information

Name of module owner/lecturer?	Dr. Breffni Tomlin
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	Mixed mode 4 hours per week
Duration of the module:	6 weeks (Dates: May / June 2011)
Assessment methods and weightings where relevant:	Final Major Essay 70% Assignments 20% Class Presentations 10%
Pass standard:	40%
Penalties for late submission of continuous assessment work:	__
Number of ECTs or institutional credits assigned to the module:	5 ECTS
Course Content or Syllabus (Optional):	Productivity in innovation: • Models and metrics; • Policies and processes to enhance quality, • Cost and time to market. Product policy: • Variety and replacement rate; • Use of the family concept; • Platforms and generational change; • Product architecture. New product development processes: • Stage-gate processes; • Managing ideation and concept development; • IT tools to support development; • Design evolution to match customer needs.
Learning Outcomes	On completion of this module students should be able to: • Understand the complexities of measurement in managing innovation. • Select an appropriate set of metrics to guide development activities. • Clearly understand the design policy options available to support rapid and customer- focussed development. • Design and implement appropriate product development processes.
Recommended Text	Cooper, Winning with New Products
Supplementary Texts	
Other relevant information	__

ICGEE Specific Information

Host Institution and School/Dept:	UCD, School of Business / NITM
Host Institution module code:	BMGT40960
Home institution QA status of module, e.g. "	Existing module on M.Sc. (Technology Management).
Rationale for including module within the ICGEE programme?	_
Resources required completing course	_

development or aid provision of course?	
Planned venue?	UCD, School of Business & Video for ICGEE
Max no. of ICGEE participants?	_
Minimum no. of participants to justify running the course?	_
Available to non-ICGEE students	Yes

8.2.4 Organisation and Innovation II Module Descriptor

Module Title:	Organisation and Innovation II
Module Status:	Currently delivered in UCD for the MSc in Technology Management

Generic Module Information

Name of module owner/lecturer?	Dr. Breffni Tomlin
Delivery mode: e.g. on-site, on-line, mixed-mode. For on-site specify contact hours per week	Mixed Mode 4 hours per week every 2nd week
Duration of the module:	12 weeks (Dates: commencing January 15th 2011)
Assessment methods and weightings where relevant:	Final Major Essay 70% Assignments & Presentations 30%
Pass standard:	40%
Penalties for late submission of continuous assessment work:	—
Number of ECTs or institutional credits assigned to the module:	5 ECTS
Course Content or Syllabus (Optional):	• Developing structures and systems appropriate to the innovation and technology strategies of the firm. • Building competences and knowledge for sustainable competitive advantage; organizing for incremental, generational and radical innovation.
Learning Outcomes	On completion of this module students should be able to: • Understand and make informed choices about outsourcing and internal Development. • Analyse an organisations environment and understand the options for acting upon it to simplify the task of organizing. Analyse and propose appropriate organisational architectures for single unit, multi-unit and multi-country companies. • Understand the options open to them in managing inter-organisational relationships and the requirements for success in implementing their chosen option. • Design organizational structures that optimize communication and control in innovation
Recommended Text	None.
Supplementary Texts	None.
Other relevant information	Assigned journal readings on blackboard

ICGEE Specific Information

Host Institution and School/Dept:	UCD, School of Business / NITM
Host Institution module code:	BMGT41020
Home institution QA status of module, e.g. "	Existing module on M. Sc. (Tech. Mgt).
Rationale for including module within the ICGEE programme?	
Resources required completing course development or aid provision of course?	None.
Planned venue?	UCD, School of Business, via Video to ICGEE
Max no. of ICGEE participants?	NA.
Minimum no. of participants to justify running the course?	NA.
Available to non-ICGEE students	Yes