EE402: OOP with Embedded Systems (Semester:1 Core)

Title:	OOP with Embedded Systems APPROVED
Long Title:	Object-Oriented Programming with Embedded Systems

Module Code:	EE402

Credits:	7.5

NFQ Level:	8

Field of Study:	Electronic Engineering

moduleLearningOutcomeTaxonomy:	Blooms

Module Delivered In	12 programme(s)

Administrator:	Jennifer McManis

Module Coordinator:	Derek Molloy

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Object-oriented Programming is a software methodology that is vital in the engineering workplace. This module will allow students to gain further experience in advanced aspects of object-oriented programming through implementation of design concepts in both the C++ and Java programming languages. Advanced embedded Linux based embedded systems are introduced in this module. Each student completes an assignment using a system-on-a-chip (SoC) device, such as the BeagleBone that involves TCP socket communications.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	analyse unseen real-world software systems challenges and develop structured solutions, involving the design of object-oriented classes and class hierarchies using formal object-oriented analysis and design models
LO2	implement such solutions in the C++ and Java programming languages with attention to future design needs and robust operation
LO3	design solutions that abstract data types through the use of approaches such as STL and generics
LO4	explain the differences between and uses of different object-oriented languages; choose a correct implementation language for the engineering problem
LO5	discuss methodologies for applying object-oriented concepts to develop solutions for real-world software implementation challenges; choose the correct methodology for a given problem
LO6	design a software application for test and reliability
LO7	develop threaded network applications from first principles that use object-oriented concepts to communicate packaged data over TCP/IP; Solve the synchronization issues associated with network computing and design network computing frameworks and solutions
LO8	discuss the use of embedded Linux under embedded systems devices and build high-level program code on an embedded Linux device; interface physical sensors/devices to the embedded Linux device, wrapping low-level electronics with high-level program code

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
Undergraduate level computer programming experience, preferably in a functional programming language. Early OOP exposure, such as EE219, is ideal.

EE402: OOP with Embedded Systems
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Brief re-introduction to object-oriented programming Discuss the concept of objects and classes in object-oriented programming languages. Discuss other concepts such as encapsulation, inheritance, polymorphism. It will quickly refresh the differences and similarities between C++ and Java related to the object-oriented paradigm.
Advanced programming Correct usage of advanced control structures and programming concepts such as exceptions, interfaces, dynamic binding, multiple inheritance, garbage collection (Java and C++). Time will be spent on low-level data structures and algorithms in C++ to ensure that students can make the connection between embedded systems skills and high-level programming skills.
Generic Programming Discussion on C++ STL and Generics in Java. Examine STL containers, iterators, algorithms and functors, and apply them to some software data structure problems (e.g. recursive tree traversal). Operator overloading. Combining Generics and Templates. Algorithms and the design of algorithms when working with C++ data structures will be covered in detail.
Software Design Methodologies Discuss methodologies for applying object-oriented concepts to develop solutions for real-world software implementation challenges. Examine object-oriented design methodologies in detail – in particular a detailed discussion on Agile Processes (including Extreme Programming (XP)).
Java Network Programming Develop network client applications that communicate to any server. Extend this work by designing servers that use network sockets to serve data to clients. Develop network computing frameworks. Ensure that these frameworks are capable of handling large volumes of requests simultaneously. Deal with the synchronization issues that arise. Students must develop a large-scale client-server application that is designed using discussed software development methodologies, generic programming concepts and correct testing.
Embedded Systems Discussion on the use of embedded systems. In-depth introduction to embedded Linux an an ARM SoC and practical application through the use of a client/server assignment that typically places the server on the embedded Linux SoC and a GUI client on the desktop machine. This architecture is described in the context of Internet of Things applications.

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	C++ and Algorithms Assignment	1,2,3	10.00	Week 7
Assignment	Java Embedded Linux Network Programming Assignment (interfacing to electronic sensors)	1,2,3,5,6,7,8	15.00	Week 12

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	1,2,3,4,6,7,8	75.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE402: OOP with Embedded Systems
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Classroom Lectures	36
Independent Study	Study of the on-line video tutorials (~10 hrs), self-directed study of the materials, completion of the assignments (~47 hrs) and study for the examinations.	152
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Derek Molloy 2014, *EE402 Object-oriented Programming Notes*, 13 Ed., ee402.eeng.dcu.ie **Derek Molloy 2015, *Exploring Beaglebone: Tools and Techniques for Building with Embedded Linux*, 1 Ed., John Wiley & Sons New York [ISBN: 1118935128]**
Supplementary / Recommended Book Resources
Deitel & Deitel 2011, *Java How to Program*, 9th Ed., Pearson Education [ISBN: 0273759760] **Harvey Deitel, Paul J.Deitel 2011, *C++ How to Program*, 8 Ed., Pearson Education [ISBN: 0136152503]** **James Gosling 1996, *The Java language specification*, Addison Wesley**
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
DME	B.Eng. in Digital Media Engineering	1	Core
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
ICE	BEng Info and Communications Engineering	1	Core
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Derek Molloy	75027429
Semester 2	Derek Molloy	75027429
Autumn	Derek Molloy	75027429

Module Teachers	
Staff Member	*Staff Email*
Derek Molloy	Derek.Molloy@dcu.ie

EE417: Web Application Development (Semester:1 Core)

Title:	Web Application Development APPROVED
Long Title:	Web Application Development
Language of Instruction:	English

Module Code:	EE417

Credits:	7.5

NFQ Level:	8

Field of Study:	Computer Software

Module Delivered In	16 programme(s)

Administrator:	Jennifer Bruton

Module Coordinator:	David Molloy

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Web application development is the process of designing, implementing, deploying, and maintaining applications on the Web. A deep understanding of web application architecture, transmission protocols, design phases, coding languages, and frameworks is required to build stable and scalable web applications. This module aims to provide students an in-depth knowledge of the skills and techniques required to develop web applications. The module will equip students with skills for client-side programming, server-side programming, and backend services e.g. databases to build modern web applications. Students will also learn how to deploy and maintain web applications.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Identify the requirements of web applications and design architecture of web applications.
LO2	Design and implement basic web applications using client-side programming.
LO3	Incrementally create and enhance web applications using server-side programming and core building blocks of web-based systems.
LO4	Create databases to store and retrieve relevant data for web applications, use back-end services to deploy database servers for web applications to query data from the database using SQL.
LO5	Implement and demonstrate a set of technologies to build and deploy a web application and apply different solutions to maintain a stable and scalable web application.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
An understanding of any functional or object-oriented programming language is *strongly recommended*. EE402 (Object Oriented Programming for Engineers) is recommended for completion prior to this module where this is possible.

EE417: Web Application Development (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Web Application Design and Architecture Introduction to web applications and web programming including the underlying architectures, technologies, and protocols for web applications.
Client-Side Programming Introduction to client-side programming for web applications including HTML and CSS. Client-Side Scripting, Javascript, and JQuery.
Server-Side Programming Server-side scripting using Node.JS and server-side programming including Java Servlets and Java Server Pages. Hosting a web application on Tomcat Web Server.
Relational Database Systems for Web Applications Designing databases for Web applications, SQL Query language, JDBC, and Hibernate.
Web Application Development Frameworks Introduction to various frameworks for web application development including AngularJS, Spring, Hibernate, Ajax, Angular, and MVC.
Web Application Deployment and Maintenance Introduction to cloud computing and deployment of web applications on the cloud. Maintaining scalability of web applications on the cloud.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Design and implement a basic Web application using HTML, CSS, and javascript.	1,2	10.00	n/a
Assignment	Enhance the existing Web application to design and implement a web application to demonstrate the concepts of client-side programming.	1,2	10.00	n/a
Assignment	Design and implement a Web application having both client-side and server-side programming and deployment of application of a web server.	3	15.00	n/a
Assignment	Design a database, create relevant datasets, and query the relevant data to dynamically create UI of web applications.	4	15.00	n/a
Project	Final Project (individual): A complete web application demonstrated using a few of the relevant technologies learned during the module and its deployment.	1,2,3,4,5	20.00	n/a
Project	Final Project (Group): A group-based project to build a complete web application for a selected list of businesses/companies.	1,2,3,4,5	30.00	n/a

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE417: Web Application Development (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	12 x 3 hour Lectures	36
Assignment Completion	Development of Web Applications	50
Independent Study	Independent Learning	101
	Total Hours	187.00

This module has no Part Time workload.

Module Resources

This module does not have any book resources
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
DME	B.Eng. in Digital Media Engineering	1	Core
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
ICE	BEng Info and Communications Engineering	1	Core
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
IFPTE	PG Int. Foundation Prog.: Telecomm.Eng	1	Core
IFPES	PG Int. Foundation Prog.(Elec. Systems)	1	Option
IFPSTE	Pre MSc Intl Foun Prog SS in Telecom Eng	1	Option
IFPSES	Pre MSc Intl. Foun Prog Sgl Sem Elec Sys	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Muhammad Intizar Ali	80367814
Semester 2	Muhammad Intizar Ali	80367814
Autumn	Muhammad Intizar Ali	80367814

Module Teachers	
Staff Member	*Staff Email*
David Molloy	David.Molloy@dcu.ie
Brendan Hayes	Brendan.Hayes@dcu.ie
Muhammad Intizar Ali	ali.intizar@dcu.ie

EE445: Bioelectronics
(Semester:1 Core)

Title:	Bioelectronics APPROVED
Long Title:	Bioelectronics
Language of Instruction:	English

Module Code:	EE445

Credits:	7.5

NFQ Level:	8

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Noel Murphy

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Bioelectronics is the application of the principles and technologies of electronic and computer systems, system modelling and electronic materials to biology and medicine, and the potential application of biological materials to solving information-processing problems. Its most immediate manifestation is in biomedical sensing and instrumentation, but a wide range of existing and potential application of electronics to biology and organic materials to information-processing problems are also part of this subject. It is a relatively new frontier for the attention of electronic and computer engineers, but its importance can only increase with the passage of time. This module includes practical lab-based, group-project-based and in-class-test-based activities, but remote students will be facilitated as far as possible to participate fully in these.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Explain and perform quantitative analysis on the physiological quantities and associated transducer characteristics that allow the sensing of clinically and health-related variables such as those relating to vital signs, metabolism, physical condition, physical activity, and bodily environment.
LO2	Design and implement appropriate electronic instrumentation and software for biosignal conditioning, amplification and digitization, and biosignal extraction or event detection relevant to clinical interpretation of data and diagnosis.
LO3	Design and conduct experiments, as well as measure, analyse, interpret and present data from living systems.
LO4	Model and analyse biological systems using the techniques of electronic and control engineering.
LO5	Explain and perform quantitative analysis on the interface between biological materials and micro- and nanoelectronics materials and devices, including the use of organic electronic material for such interfacing.
LO6	Explain commercial, regulatory, ethical and practical hurdles in the development of medical device electronics.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE445: Bioelectronics
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Module Introduction Module outline, learning outcomes, assessment and reference materials; introduction to the BIOPAC Student Lab.
Action Potentials and Sources of Biopotentials - the Heart and the Nervous System The human cell structure; cell membrane ion transport; the mechanisms of action potentials; bioelectric potentials at the skin surface; how the cardiovascular system gives rise to the electrocardiogram (ECG); the electrocardiogram waveform structure and interpretation. The neuron and the structure of the central nervous system; the role of and operation of synapses; the structure of the brain; the electroencephalogram (EEG) format and interpretation; muscle action and the electromyogram (EMG).
Biopotential Electrodes The redox reaction, half-cell potential, electronegativity and polarisation; equivalent electric circuit for a biopotential electrode in an electrolyte; equivalent circuit for an electrode on skin; types of electrode; stimulating vs measurement electrodes.
The Electrocardiograph (ECG) The electrical activity of the heart; the cardiac vector; ECG leads; Einthoven's triangle, augmented leads and precordial leads.
Biopotential Amplifiers Common Mode Rejection Ratio (CMRR); instrumentation amplifier; noise sources; driven right leg; transient protection and AC signal coupling; transformer, capacitive and optically-coupled isolation amplifiers; conditioning amplifiers; signal averaging for noise reduction; calculating system noise factors and noise figures.
Blood Pressure Measurement Direct (invasive) measures of blood pressure measurement such as catheter-connected pressure sensors; the Korotkoff method and the sphygmomanometer; the oscillometric method, including two-band instrumentation amplifiers; doppler (ultrasound) method; blood pressure finger gauge/photoplethysmogram (PPG); tonometry; pulse transit time.
Measuring Respiration Impedance plethysmography; 2-electrode and 4-electrode systems; inductance plethysmography; ECG-derived respiration (EDR); EDR signal processing methods.
Defibrillators & Pacemakers Types of heart arrhythmia; defibrillation; defibrillation waveforms; synchronized electrical cardioversion; pacing modes.
Branches of Bioelectronics Organic bioelectronics; Bioelectronic components; Biosensors; Fuel Cells; Biomimetic systems; Bionics; Brain–machine interfaces; Lab-on-a-chip.
Organic Bioelectronic Materials and Devices Conducting organic polymers; the organic electrochemical transistor (OECT); organic field-effect transistors (OFETs); ion-sensitive OFETs (IS-OFETs); organic electronic ion pump (OEIP); conducting polymers as electrodes; ion-sensitive field-effect transistor (ISFET); immunologically sensitive field-effect transistor (IMFET); optical biochemical transducers; optical measurement of blood oxygen saturation.
Grossberg Neural Models of the Human Visual System The role of visual paradoxes and illusions in explaining our perception of form and colour; the boundary contour and feature contour systems; possible neural mechanisms.
Commercial, regulatory, ethical and practical hurdles in the development of medical devices Electrical safety; patient safety; ethical issues; regulatory issues; data protection issues; the changing relationship between the patient and the medic.
Further Topics These may vary from year to year but presently include: How birds sense the Earth's Magnetic field; Insect Communication by Infrared Radiation; Information storage in DNA; Bio computers.

Assessment Breakdown	%
Continuous Assessment	30.00%
End of Academic Session	70.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
In Class Test	There will be a short MCQ test at the beginning of each 3-hour timetabled session to encourage students to engage with assigned reading and research relevant to the session topic. This will be implemented through Loop, and remote students will be able to participate synchronously.	1,2,5,6	8.00	n/a
Group laboratory	During the first half of semester, groups of students will conduct set exercises using the BIOPAC Student Lab system to reinforce and give practical insight into the concepts being introduced in lectures. These labs will take place during the 3-hour timetabled slot, and remote students will be facilitated in participating using in-lab videoing of the exercises and exchange of captured data to enable remote data analysis and reporting.	1,2,3	8.00	n/a
Group project	The design-and-make project is a group-based activity to be carried out as far as possible during the 3-hour timetabled slots mostly in the second half of semester. Where groups include remote students, the group will need to use synchronous or asynchronous means for cooperation collectively achieving the project objectives. An example of the project is to develop, demonstrate and report on an end-to-end Internet of Things application involving a cardiac sensor, though the specific task may vary from year to year.	1,2,3	14.00	Week 12

End of Module Formal Examination				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	Three-hour written exam paper.	1,2,4,5,6	70.00	End-of-Semester

Reassessment Pre-Requisite
Repeat examination *Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.*
Reassessment Description The exam element of the module assessment will be reassessed by a resit exam in August. A combination of a single (larger) MCQ test and an individual student assignment may be used to reassess the CA element of the module assessment.

DCU reserves the right to alter the nature and timings of assessment

EE445: Bioelectronics
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Assignment Completion	No Description	20
Independent Study	No Description	131.5
	Total Hours	187.50

This module has no Part Time workload.

Module Resources

Supplementary / Recommended Book Resources

John G. Webster, editor; contributing authors, John W. Clark, Jr.... [et al.] 2010, *Medical instrumentation*, 4th Ed., John Wiley & Sons Hoboken, NJ [ISBN: 9780471676003]

C.R. Rao, S.K. Guha 2001, *Principles of Medical Electronics and Biomedical Instrumentation*, Universities Press,India [ISBN: 8173712573]

R. S. Khandpur 2005, *Biomedical instrumentation*, McGraw-Hill New York [ISBN: 0071447849]

Ronald R. Pethig,ՙStewart Smith 2012, *Introductory Bioelectronics: For Engineers and Physical Scientists*, Wiley-Blackwell [ISBN: 978-111997087]

Sandro Carrara (Editor),ՙKrzysztof Iniewski (Editor) 2015, *Handbook of Bioelectronics: Directly Interfacing Electronics and Biological Systems*, Cambridge University Press [ISBN: 978-110704083]

Andreas Offenhäusser, Ross Rinaldi (Eds) 2010, *Nanobioelectronics - for Electronics, Biology, and Medicine*, Springer [ISBN: 978144191857]

Michael S. Gazzaniga, University of California, Santa Barbara; Richard B. Ivry, University of California, Berkeley; George R. Mangun, University of California, Davis., *Cognitive neuroscience*, New York; W. W. Norton & company, inc [ISBN: 0393913481]

Humberto R. Maturana,ՙFrancisco J. Varela 1992, *The Tree of Knowledge: The Biological Roots of Human Understanding*, Shambhala [ISBN: 0877736421]

Supplementary / Recommended Article/Paper Resources

Owens, R., & Malliaras, G. 2010, *Organic Electronics at the Interface with Biology*, MRS Bulletin, 35(6), 449-456. doi:10.1557/mrs2010.583

Faria, G., Duong, D., Salleo, A., Polyzoidis, C., Logothetidis, S., Rivnay, J., . . . Malliaras, G. 2014, *Organic electrochemical transistors as impedance biosensors*, MRS Communications, 4(4), 189-194. doi:10.1557/mrc.2014.35

Martin, D.C., Malliaras, G.G 2016, *Interfacing Electronic and Ionic Charge Transport in Bioelectronics*, ChemElectroChem, 2016, 3, 686 – 688

Other Resources

Website: Institute for Systems Biology*What is Systems Biology?*, Institute for Systems Biology
https://www.systemsbiology.org/about/wha t-is-systems-biology/

Website: Stephen Grossberg*Stephen Grossberg Academic Homepage*
http://cns.bu.edu/Profiles/Grossberg/

Website: Nelson Vaz*Francisco Varela and the Immunological Self*
http://www.academia.edu/4740894/Francisc o_Varela_and_the_Immunological_Self

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Noel Murphy	75006979
Semester 2	Noel Murphy	75006979
Autumn	Noel Murphy	75006979

Module Teachers	
Staff Member	*Staff Email*
Noel Murphy	Noel.Murphy@dcu.ie

EE452: Wireless/Mobile Communications (Semester:1 Core)

Title:	Wireless/Mobile Communications APPROVED
Long Title:	Wireless/Mobile Communications

Module Code:	EE452

Credits:	7.5

NFQ Level:	8

Field of Study:	Electronic Engineering

Module Delivered In	11 programme(s)

Administrator:	Jennifer Bruton

Module Coordinator:	Muhammad Intizar Ali

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The aim of the module is to introduce students to the design of wireless networks and in particular to illustrate the differences between fixed and mobile voice and data networks. Students will gain in-depth knowledge of the underlying architectures of wireless communication systems and standards, physical layer, MAC, and network layer. The design and planning of a wireless network considering its critical limitations and performance issues. The design of cellular networks will be motivated in terms of the properties of wireless signal transmission and the evolution of cellular network technologies. Understanding of various wireless networks standard including LAN, MAN, short and long-range networks, and a combination of networks. Introduction of wireless sensor networks and their application for the Internet of Things.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Explain various wireless communication networks, identify critical limitations and issues, compare various wireless communication networks.
LO2	Calculate and compare the signal loss models, performance of various signal modulation techniques, spread spectrum techniques and codes.
LO3	Explain the evolution of cellular networks, data transmission, and handover techniques.
LO4	Explain and compare various wireless network standards and plan a suitable wireless network for a given application. Troubleshoot network problems and performance monitoring.
LO5	Understand wireless sensor networks and related technologies to plan a wireless network for an IoT application.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
none

EE452: Wireless/Mobile Communications (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Introduction Introduction to the wireless communication networks, the difference between wired and wireless techniques. Limitation and network issues. Applications of wireless networks.
Wireless Networks History of the wireless networks, radio transmission, antennas and propagation, loss models, signal encoding.
Cellular Networks Introduction to cellular networks, history and evolution of cellular networks 1G to 5G, design of cellular networks, channel reuse, signal interference, and network traffic engineering and monitoring. Mobility and handover techniques and their comparison.
Wireless Networks Standards Explain various wireless network techniques and architectures. Plan, design, deploy, and simulate wireless networks including LAN and MAN considering constraints and performance issues including quality of services and network traffic analysis.
Wireless Sensor Networks Introduction to wireless sensor networks, long and short-range wireless communication protocols, ad hoc networks, and their applications for the Internet of Things.

Assessment Breakdown	%
Continuous Assessment	50.00%
End of Academic Session	50.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Design and implement small scale wireless LAN	1,2	20.00	n/a
Project	Plan a wireless network and network technology for a given application or environment.	3,4,5	30.00	n/a

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	1,2,3,4,5	50.00	End-of-Semester

Reassessment Pre-Requisite

Repeat examination
Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.

DCU reserves the right to alter the nature and timings of assessment

EE452: Wireless/Mobile Communications (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Assignment Completion	1 Assignment and 1 Project	50
Independent Study	No Description	101
	Total Hours	187.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
William Stallings 2005, *Wireless Communications*, 2 Ed., Pearson/Prentice Hall
Supplementary / Recommended Book Resources
William Stallings 2008, *Data and Computer Communications*, 8 Ed., Prentice Hall
Essential Article/Paper Resources
John Scourias *Overview of the Global System for Mobile Communications*
Other Resources
n/a: *GPRS overview* http://www.radio-electronics.com/info/ce llulartelecomms/gprs/gprs_tutorial.php **n/a: *UMTS overview*** http://www.radio-electronics.com/info/ce llulartelecomms/umts/umts_wcdma_tutorial .php **n/a: *WCDMA*** http://privateline.com/ **n/a: *Bluetooth Tutorial*** http://www.palowireless.com/infotooth/tu torial.asp **n/a: *The Nuts and Bolts of WiMAX*** http://www.embedded.com/columns/technica linsights/201802589?cid=RSSfeed_embedded _news **n/a: IEC*OFDM for mobile and data communications*** http://www.iec.org/online/tutorials/ofdm /

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
ICE	BEng Info and Communications Engineering	1	Core
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Muhammad Intizar Ali	80367814
Semester 2	Muhammad Intizar Ali	80367814
Autumn	Muhammad Intizar Ali	80367814

Module Teachers	
Staff Member	*Staff Email*
Jennifer McManis	Jennifer.McManis@dcu.ie
Muhammad Intizar Ali	ali.intizar@dcu.ie

EE453: Image Processing & Analysis (Plus) (Semester:1 Core)

Title:	Image Processing & Analysis (Plus)
Long Title:	Image Processing & Analysis (Plus)
Language of Instruction:	English

Module Code:	EE453

Credits:	7.5

NFQ Level:	8

Field of Study:	Artificial Intelligence & Signal & Image Processing

moduleLearningOutcomeTaxonomy:	Blooms

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Paul Whelan

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Most people are familiar with the concept of processing an image to improve its quality or the use of image analysis software tools to make basic measurements; but what are the ideas behind such solutions and why is knowledge of these concepts important in developing successful computer vision applications? This module will answer these questions by focusing on both the theoretical, mathematical and practical issues associated with a wide range of computer vision solutions. Such solutions relate to the fields of image processing & analysis, industrial/machine vision, video data processing, biomedical engineering, imaging science, sensor technology, multimedia and enhanced reality systems. This module will concentrate on developing the fundamentals necessary to design, develop and understand a wide range of basic imaging processing (image to image), image analysis (image to feature), image classification (feature to decision), performance characterisation (data to quantitative performance indicators) and computer vision (image to interpretation) solutions. All solutions have limitations and a key element of this module is to focus on how to approach the design, testing and evaluation of successful computer vision applications within an engineering framework. This module will make extensive use of an image analysis development environment to reinforce all the issues covers during the lectures. In addition to the common elements associated with EE425, this module will develop on these core ideas to expand into more advanced IPA engineering topics.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Recall, review and analyse the essential theories, algorithms, methodologies and techniques involved in basic and advanced computer vision.
LO2	Illustrate their ability to comprehend and interpret issues relating to the design of image processing & analysis techniques.
LO3	Synthesize and evaluate the relevant merits of competing computer vision techniques.
LO4	Apply computer vision techniques in a range of application scenarios.
LO5	Develop an understanding of the engineering issues involved in the commercial development of image processing and analysis solutions.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
This module will require basic programming skills. The course makes use of a standard image analysis environment to keep the students focus on the issues relating to image processing and analysis solutions design rather than programming. The module will also require basic undergraduate engineering mathematics (e.g. matrices, vectors, differential equations, Fourier, trigonometry, algebra ...) with a particular focus on discrete systems. Selected mathematical concepts will be revisited throughout the module.

EE453: Image Processing & Analysis (Plus) (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Introduction • Introduction to the software development environment for Image Processing & Analysis • IPA Pipeline • Learning Outcomes • Module Protocol • Assessment Requirement • Code Development • Support Material & Website • Human/Computer/Machine Vision • Ethics • Case Studies.
Basic Techniques • Image Representation • Point Operators • Thresholding • Local Operators • Non-linear Local Operators • Template Matching • Histograms • Binary Images • Simple Shape Descriptors • Edge Detection • Corner Detector
Morphology • Binary Mathematical Morphology • Grey Scale Morphology • Top-Hat Transform • Covariance • Conditional Dilation • Reconstruction by Dilation • Opening/Closing by Reconstruction
Transforms • Global Image Transforms • Distance Transform • Hough Transform • Two-dimensional Discrete Fourier Transform
Classification & Performance Characterisation • Supervised vs Unsupervised • Feature Selection • Nearest Neighbour Classifier (KNN) • Maximum-likelihood Classifier • Performance Characterisation
Colour • Human Perception of Colour • Colour Spaces • Colour Scattergrams • Programmable Colour Filter
Texture • Histogram Features • Co-occurrence (Matrix) Approach • Morphological Texture Analysis • Local Binary Patterns (LBP)
Systems Engineering • Optical Terminology • Lenes & Filters • Monochrome Aberrations • Lighting Design • Image Sensors • Chromatic Aberrations • Pixel Level Effects
3D Imaging • Passive Stereoscopic Methods • Camera Calibration • Shape from Stereo • Image Rectification • Stereo Feature Matching • Colour / Multiple Views Stereo Vision • Active Stereoscopic Methods

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Practical/skills evaluation	Practical Assignment		25.00	

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination		75.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE453: Image Processing & Analysis (Plus) (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	This module is presented in a traditional format (lecture and continuous assessment) with significant practical support [including: long-format electronic notes and associated course text, pdf versions of the class slides, lecture screencasts, image analysis development environment (used for the assignments and to illustrate computer vision concepts), self assessment questions and selected examples illustrating key concepts].	36
Laboratory	Laboratory support for coursework & tutorials	12
Independent Study	General revision and practice, Coursework, Online activity with module material. Homeworks and tutorials.	139.5
	Total Hours	187.50

This module has no Part Time workload.

Module Resources

Essential Book Resources
Paul F Whelan, *Online Course long form notes (including self assessment questions) and class notes (slides)*
Supplementary / Recommended Book Resources
Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer **Paul F. Whelan, Derek Molloy, *Machine Vision Algorithms in Java*, Springer** **E. R. Davies, *Machine vision*, Elsevier**
This module does not have any article/paper resources
Other Resources
Module Website: *EE453* https://www.eeng.dcu.ie/~whelanp/ipa/ipa_notes.html **Lecturer Website: *paulwhelan.eu*** http://paulwhelan.eu/

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Paul Whelan	75015803
Semester 2	Paul Whelan	75015803
Autumn	Paul Whelan	75015803

Module Teachers	
Staff Member	*Staff Email*
Paul Whelan	Paul.Whelan@dcu.ie

Discussion Note:	remove references to matlab

EE454: Optical Communications System Design (Semester:1 Core)

Title:	Optical Communications System Design APPROVED
Long Title:	Optical Communications System Design

Module Code:	EE454

Credits:	7.5

NFQ Level:	8

Field of Study:	Environmental Science

Module Delivered In	14 programme(s)

Administrator:	Noel Murphy

Module Coordinator:	Liam Barry

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To introduce the student to the main components of an optical communications system and to describe typical communication systems which employ optical techniques.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Identify the main parameters of laser diodes, optical fibre, and optical receivers that effect the performance of optical communications systems
LO2	Analyse the equations that explain the modulation of an optical carrier with electrical data signals and apply these equations to determine the maximum modulation rate that can be attained
LO3	Derive solutions for how non-linearity and dispersion affect the propagation of data signals in optical fibre, and apply these solutions to analyse the maximum data rate and transmission distance of optical transmission links
LO4	Determine the various parameters of an optical receiver that affect Bit-Error-Rate and eye diagrams, and identify how an eye-diagram may be used in quantifying system performance
LO5	Identify the different type of networking configurations that may be used in an optical network and analyse how component selection effects network design
LO6	Design a basic optical communication systems and analyse how it performance would be effected by the various components used in the system design
LO7	Implement a wavelength division multiplexed systems and formulate how altering the parameters of the components used would change system capacity
LO8	Operate all the main components required to develop a basic optical communication systems, and conduct experiments to develop and analyse an optical transmission system

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE454: Optical Communications System Design
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Optical Communications System Design Properties of Optical Fibres: fibre types; step-index and graded-index; monomode and multimode;. Lasers and Modulation Techniques: the laser diode; power spectrum; single-mode lasers; direct modulation; intensity modulation; frequency modulation; linearity; pulse modulation; coding an optical carrier. Signal Degradation and Coupling Efficiency: absorption; scattering; radiative losses; core and cladding losses; material dispersion; waveguide dispersion; intermodal dispersion; nonlinear effects; mode coupling; source-to-fibre power launching. Demodulation: photodiodes; construction; temperature effects; response time; direct detection; signal-to-noise ratio with direct detection of intensity modulated waves. Multiplexing: time-division multiplexing; limitations of TDM; wavelength division multiplexing; WDM using optical filters; cross-talk; radio-frequency subcarrier multiplexing. Fibre-Optic Networks: WDM networking, structure. Evolution to All-Optical Networks.

Assessment Breakdown	%
Continuous Assessment	20.00%
End of Academic Session	80.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Undertake Lab work and submit an assignment based on the results of this lab work		20.00	

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination		80.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE454: Optical Communications System Design
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Taught lectures	33
Assignment Completion	Written assignement for submission which counts as the CA part of this module	17
Laboratory	Time spent understanding lab manual and undertaking experimental work in the lab	10
Tutorial	Tutorial	3
Independent Study	Independent learning and studying	120
	Total Hours	183.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Gerd Keiser, *Optical fiber communications*, Boston [etc.] McGraw-Hill 2000 [ISBN: 9780072321012]
Supplementary / Recommended Book Resources
Govind P. Agrawal, *Fiber-Optic Communication Systems*, Wiley [ISBN: 9780470505113] **Christopher C. Davis, *Lasers and electro-optics*, Cambridge [England] ; Cambridge University Press, 1996. [ISBN: 9780521484039]** **Rajiv Ramaswami, Kumar Sivarajan, Galen Sasaki, *Optical Networks*, Morgan Kaufmann [ISBN: 9780123740922]**
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
EE	BEng in Electronic Engineering	1	Core
EE	BEng in Electronic Engineering	1	Core
ICE	BEng Info and Communications Engineering	1	Core
ICE	BEng Info and Communications Engineering	1	Core
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Liam Barry	75043394
Semester 2	Liam Barry	75043394
Autumn	Liam Barry	75043394

Module Teachers	
Staff Member	*Staff Email*
Prince Anandarajah	Prince.Anandarajah@dcu.ie
Liam Barry	Liam.Barry@dcu.ie
Colm Browning	Colm.Browning@dcu.ie

EE459: Mechatronic System Simulation & Control (Semester:1 Core)

Title:	Mechatronic System Simulation & Control APPROVED
Long Title:	Mechatronic System Simulation & Control

Module Code:	EE459

Credits:	7.5

NFQ Level:	8

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Mingming Liu

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The purpose of this module is to further develop students' competencies in mechatronic system analysis and design. It deals with combined electrical, electronic and mechanical systems, control system design, nonlinear analysis and appropriate software tools.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	conduct the required background research related to mechatronic systems and control and be able to search for, access, review and evaluate publications on given related topics
LO2	develop and analyse system models for electronic, mechanical, electro-mechanical and other systems
LO3	design appropriate continuous and discrete -time control systems
LO4	critically evaluate the effectiveness of controller designs for physical systems
LO5	present and apply simulation theory for physical system modelling and control
LO6	implement the simulation and control of electromechanical systems using appropriate software tools
LO7	analyse the behaviour of nonlinear elements common to mechantronic systems using graphical frequency and state-space response techniques
LO8	effectively discuss the design, simulation, modelling and analysis of mechatronic or related systems by written means

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
EM207 & EE314 or equivalent.

EE459: Mechatronic System Simulation & Control (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Analysis of mixed electrical, electronic and mechanical systems. Analysis of mixed electrical, electronic and mechanical systems in the time domain, in the frequency domain and in state space.
Control systems. Control system design. Quantitative analysis of the quality of control offered by a control system design. The selection and use of appropriate software tools for design, analysis and evaluation of control systems.
Simulation. Appropriate software tools. Numerical methods, including numerical optimization.

Assessment Breakdown	%
Continuous Assessment	30.00%
End of Academic Session	70.00%

Continuous Assessment				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Computer-based electromechanical systems analysis.	1,2,4,6,8	15.00	Once per semester
In Class Test	Computer based simulation & analysis	2,5,6,8	15.00	Once per semester

End of Module Formal Examination				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	2,3,4,5,6,7,8	70.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE459: Mechatronic System Simulation & Control (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Lecture	36
Laboratory	Computer-based laboratories	30
Directed learning	In class test/lab	2
Independent Study	Preparation for laboratories	10
Independent Study	Preparation for Assessment	10
Assignment Completion	Research based assignment	30
Independent Study	On-line activity with module material	20
Independent Study	Preparation for final exam	50
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources

Richard C. Dorf, Robert H. Bishop 2011, *Modern control systems*, Pearson Prentice Hall Upper Saddle River, N.J. [ISBN: 9780136024583]

Supplementary / Recommended Book Resources

Norman S. Nise 2012, *Control Systems Engineering*, John Wiley & Sons Ltd [ISBN: 9780470646120]

Clarence W De Silva 2005, *Mechatronics - An Integrated Approach*, CRC Press

Sergey E Lyshevski 2008, *Electromechanical Systems and Devices*, CRC Press

Katsuhiko Ogata., *Modern control engineering*, Boston; Pearson [ISBN: 9780137133376]

This module does not have any article/paper resources

Other Resources

Website: Jennifer Bruton*EE451 Module Material*
http://ee451.eeng.dcu.ie

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Mingming Liu	80366842
Semester 2	Mingming Liu	80366842
Autumn	Mingming Liu	80366842

Module Teachers	
Staff Member	*Staff Email*
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Patrick Bradley	Patrick.Bradley@dcu.ie
Mingming Liu	Mingming.Liu@dcu.ie

EE463: Solid State Electr. & Semiconductor Devices (Semester:1 Core)

Title:	Solid State Electr. & Semiconductor Devices APPROVED
Long Title:	Solid-State Electronics and Semiconductor Devices

Module Code:	EE463

Credits:	7.5

NFQ Level:	8

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Patrick McNally

Module Coordinator:	Patrick McNally

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The operation of modern semiconductor devices is underpinned by a good knowledge of the physics of solid-state materials and electronics. This module is motivated by the need to link physical models with modern device operation. The module uses basic quantum mechanical physical principles to explain the properties of materials of interest in electronic engineering practice. A knowledge of the bonding between atoms is essential to understand the behaviour of solids and their electronic properties, which distinguish conductors from semiconductors and insulators. These impact on the electronic properties of materials, which in turn control the operation of electronic devices currently used and under development. Building on this foundation of solid-state physics the module introduces the student to the basic parameters which control the behaviour of electronic devices, such as diodes, bipolar transistors, MOSFETs and lasers. The phenomena which occur in non-idealized devices are studied and the behaviour of real devices is examined in the light of these phenomena.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Differentiate between simple cubic, face centred cubic and body centred cubic crystaline structures.
LO2	Describe electrical conduction in metals using the Drude model.
LO3	Apply the Schrodinger wave equation (SWE) to explain quantum mechanical phenomena such as tunnelling.
LO4	Describe the behaviour of electrons in a potential well and extend this knowledge to the motion of electrons in a periodic structure.
LO5	Differentiate between insulators, semiconductors and metals utilising concepts such as bandstructure, Fermi-Dirac statistics, effective mass etc.
LO6	Calculate the position of the extrinsic Fermi Level in doped semiconductors.
LO7	Explain Schottky, Ohmic and Neutral contacts; design such junctions and calculate the depletion region widths.
LO8	Explain and calculate the I-V characteristics of pn junctions, including the calculation of diffusion and drift contributions to currents, and transient charge storage phenomena.
LO9	Explain the operation of bipolar junction transistors (BJT) using the Ebers-Moll model.
LO10	Describe MOSFET I-V and switching characteristics.
LO11	Explain the basic operation of a solar cell device.
LO12	Explain the basic operation of the laser.
LO13	Explain how real devices are fabricated, including critical semiconductor wafer processing steps.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE463: Solid State Electr. & Semiconductor Devices (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Indicative Syllabus Crystal Structure. Atoms, lattices, symmetries, crystals. Common systems: simple cubic, face centred cubic and body centred cubic crystaline structures. The Drude model of electronic conduction. Breakdown of the Drude model and the need for quantum mechanics. The Schroedinger Wave Equation: Particle in a box. Tunnelling. Electron Waves and the periodic lattice potential. Band structure, Fermi-Dirac statistics, effective mass. Intrinsic and extrinsic semiconductors. Impact of doping. Metal-Semiconductor Contacts. Depletion region widths. PN Junctions. I-V characteristics. Calculation of diffusion and drift contributions to currents, and transient charge storage. Bipolar Junction Transistors (BJTs). The Ebers-Moll model. Metal-Oxide-Semiconductor Field Effect Transistors (MOSFETs). I-V and switching characteristics. Advanced device concepts: Solar cell and lasers. Semiconductor device fabrication. Oxides, metals, doping, etch and deposition techniques, interconnect, packaging.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Laboratory Portfolio	A series of two laboratory-based exercises with a particular focus on the fundamentals of Quantum Mechanics (Lab #1: the measurement of the Photoelectric Effect) and the operation of metal-semiconductor junctions (Lab #2: characterisation and analysis of Schottky diodes and the implications of the ideality factor).	2,3,4,5,6,7	20.00	n/a
Assignment	A substantial Design Project, which probes the student's ability to assimilate material learned in class in order to meet a strict set of design rules, which would exist in a manufacturing company. Fundamental materials device physics (doping) is tied to device design, e.g. chose doping regimes in a silicon epilayer structure, in order to implement a functioning junction-based device. This device design is done in the context of nanofabrication steps such as ion implantation, diffusion profiles, layout, etc. There is NO SINGLE CORRECT design and it is expected that each student design will be individual.	1,2,3,4,6,8,12	40.00	n/a
Assignment	A substantial Design Project, which probes the student's ability to assimilate material learned in class in order to meet a strict set of design rules, which would exist in a semiconductor device fabrication. In this situation the students will design a functioning transistor device which must meet a series of breakdown, resistance and gain specifications. The students are supplied with a nominal set of process specifications, e.g. minimum tolerances for junction depths, highest effective doping that can be manufactured. After the students have completed their device design, a series of additional questions will be answered to probe their understanding of the implications of altering design.	7,8,9,10,11,12,13	40.00	n/a

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE463: Solid State Electr. & Semiconductor Devices (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Formal iectures: synchronous and asynchronous	36
Fieldwork	Laboratory analysis in support of class lectures.	20
Assignment Completion	Design Projects 1 & 2 in support of class lectures.	60
Independent Study	Independent study and learning	72
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Simon M. Sze & Ming-Kwei Lee 2012, *Semiconductor Devices: Physics and Technology*, 3rd International Student Version Ed., John Wiley & Sons USA [ISBN: 978-0470873670]
Supplementary / Recommended Book Resources
S. O. Kasap 2006, *Principles of Electronic Materials and Devices*, 3rd Ed., McGraw-Hill Boston, USA [ISBN: 978-0073104645] **Kevin F. Brennan 2010, *Introduction to Semiconductor Devices: For Computing and Telecommunications Applications*, 1st Ed., Cambridge University Press UK [ISBN: 978-0-521-15361-4]**
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Patrick McNally	75018535
Semester 2	Patrick McNally	75018535
Autumn	Patrick McNally	75018535

Module Teachers	
Staff Member	*Staff Email*
Patrick McNally	Patrick.McNally@dcu.ie

EE488: Mathematical Techniques and Problem Solving (Semester:1 Core)

Title:	Mathematical Techniques and Problem Solving APPROVED
Long Title:	Mathematical Techniques and Problem Solving
Language of Instruction:	English

Module Code:	EE488

Credits:	7.5

NFQ Level:	8

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Jennifer Bruton

Module Coordinator:	Conor Brennan

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The aim of this module is to provide the opportunity to students taking Masters-level modules in the School of Electronic Engineering to ensure that they have acquired or regained the mathematical knowledge and competencies necessary to successfully undertake these Masters modules. While the coverage is targeted on prerequisites for a range of Masters modules, the emphasis is on practical applications of the relevant concepts and techniques. Hence, a student who has covered some or all of these topics previously and just needs to recap them is still likely to have a valuable learning experience on this module. The module may also be taken as a standalone module in its own right as providing a valuable foundation for the application of mathematics in industry and technology.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	demonstrate that they recognise the role of numerical, analytical, algebraic and algorithmic approaches to solving engineering problems
LO2	choose the appropriate mathematical method to solve a problem, recognising the strengths and limitations of various methods
LO3	derive mathematical formulas or models for solving particular problems from a generic starting point
LO4	design, implement, test and characterize an appropriate mathematical approach to a given engineering problem described in general terms
LO5	demonstrate that they can communicate technical results from engineering problems solved using mathematical approaches, including using graphical and statistical tools
LO6	demonstrate an ability to work collaboratively in a team environment to solve engineering problems using mathematical and algorithmic tools

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE488: Mathematical Techniques and Problem Solving (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Linear Maths Review of linear algebra, vector spaces, matrix algebra, eigenvector decomposition, singular value decomposition, numerical applications and problem solving, including solutions to sets of linear equations; polynomial curve fitting; iterative techniques and applications.
Numerical approximations for differential and integral calculus Taylor's theorem, linear approximation and numerical methods in differentiation and integration, including Richardson Extrapolation and Simpson's rule.
Multivariate and complex-valued functions and calculus Review of complex-valued functions, vector-valued functions and vector fields; differentiation in multi-dimensions, linear approximation of multi-variate functions, max/min problems, chain rule, directional derivatives, gradient vector field; multiple integrals; vector analysis (div and curl of vector fields), line integrals, work, circulation and flux, Green's Theorem and Stokes' Theorem; complex analysis and contour integration.
Numerical solution of ordinary and partial differential equations Numerical solution of ordinary differential equations; boundary-value PDE problems and their solution, including Runge Kutta methods.
Series representations and Transform Theory Theory and properties of the Fourier series, Fourier Transform, Laplace transform, Z-transform; other orthogonal transforms; transform theory in the solution of ordinary differential and difference equations.
Statistics Statistical analysis, histograms and descriptive statistics; statistical significance, confidence intervals, hypothesis testing, linear regression and analysis of variance.
Random Signals and Systems Stochastic signals, random variables and probability; birth-death process and introduction to queuing theory.
Algorithmic Maths for Engineering Applications Problems in networks and graphs, coding, searching and optimisation problems, statistical methods, Monte Carlo method, computing discrete transforms and signal processing applications. Parallelizable algorithms. Numerical limitations of finite precision machines.

Assessment Breakdown	%
Continuous Assessment	50.00%
End of Academic Session	50.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Group project	Computer-based assignment to solve a given engineering problem by selecting, implementing, testing and characterizing appropriate mathematical approaches.	1,2,3,4,5,6	25.00	n/a
Assignment	A series of 'homework' problems completed by students working individually to practice and reinforce concepts met during in-class activities	1,2,3,4,5	10.00	As required
In Class Test	A short MCQ at the beginning of each lecture session to encourage students to engage with assigned reading and research relevant to the session topic.	1,2,5	15.00	Every Week

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-semester final written or computer-based examination	1,2,3,4,5	50.00	End-of-Semester

Reassessment Pre-Requisite

Repeat examination
Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.

DCU reserves the right to alter the nature and timings of assessment

EE488: Mathematical Techniques and Problem Solving (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Classroom or computer lab-based activities involving both lecturer and student-based input	36
Group work	Group-based assignment work	30
Assignment Completion	Homework problems	24
Independent Study	Pre-lecture preparation through prescribed reading, independent study post lectures, informal tutor-supported study sessions if required	98
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Supplementary / Recommended Book Resources

Erwin Kreyszig 2011, *Advanced Engineering Mathematics*, 10 Ed., John Wiley & Sons Ltd [ISBN: 0470646136]

K A Stroud 2011, *Advanced Engineering Mathematics*, 5 Ed., Palgrave Macmillan [ISBN: 0230275486]

W. Bolton, *Mathematics for engineering*, Oxford ; Newnes, 2000. [ISBN: 0750649313]

Peter V. O'Neil, *Advanced Engineering Mathematics*, Cengage India; 7 edition (2012) [ISBN: 8131517527]

Robert Sedgewick, Kevin Wayne, *Algorithms*, Addison-Wesley Professional [ISBN: 032157351X]

Holly Moore, *Matlab for Engineers*, Pearson; 5 edition (January 14, 2017) [ISBN: 0134589645]

D. Pearson 1996, *Calculus and ODEs*, Edward Arnold London [ISBN: 0340625309]

John H. McColl 1995, *Probability*, Edward Arnold London [ISBN: 0340614269]

A. Chetwynd and P. Diggle 1995, *Discrete mathematics*, Arnold London [ISBN: 0340610476]

R. B. J. T. Allenby 1995, *Linear algebra*, Edward Arnold London [ISBN: 0340610441]

Peyton Z Peebles 2015, *Probability, Random Variables, and Random Signal Principles*, McGraw-Hill [ISBN: 1259007642]

Gene H. Golub, Charles F. Van Loan, *Matrix Computations*, 4th Ed., The Johns Hopkins University Press [ISBN: 9781421407944]

E. Oran Brigham 1988, *The fast Fourier transform and its applications*, Prentice Hall Englewood Cliffs, N.J. [ISBN: 0133075052]

Tristan Needham 1998, *Visual complex analysis*, Clarendon Press Oxford [ISBN: 0198534469]

This module does not have any article/paper resources

This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Conor Brennan	80007139
Semester 2	Conor Brennan	80007139
Autumn	Conor Brennan	80007139

Module Teachers	
Staff Member	*Staff Email*
Conor Brennan	Conor.Brennan@dcu.ie

EE497: 3D Interface Technologies (Semester:1 Core)

Title:	3D Interface Technologies APPROVED
Long Title:	3D Interface Technologies
Language of Instruction:	English

Module Code:	EE497

Credits:	7.5

NFQ Level:	8

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Robert Sadleir

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	This module deals with the visualisation of / interaction with acquired and synthetic 3D data. The topics covered include: 3D data acquisition, the mathematical fundamentals of 3D graphics, 3D application development for web and mobile platforms, rendering techniques for use with volumetric data and advanced 3D visualisation systems. The assessment of the module consists of a terminal examination and an assignment where the student created a bespoke sensor driven immersive 3D visualisation system.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Understand and apply the mathematical concepts relating to 3D user interface design
LO2	Integrate bespoke 3D computer graphics software with the appropriate sensors to create sensor driven immersive 3D visualisation systems
LO3	Understand and apply the design processes relating to mobile application development and 3D application development in both familiar and unfamiliar situations
LO4	Design and conduct experiment to determine the performance and accuracy of a bespoke 3D user interface.
LO5	Understand the concepts from physics and medicine that relate to the acquisition of medical image data and explain the ethical issues associated with the acquisition of 3D data in this context
LO6	Succinctly describe the relevant advantages and disadvantages of their own 3D interface system; write reports and summarise their own work in abstracts; act on instructions related to the development of a bespoke 3D interface system and give clear instructions explaining how the developed system should be used

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
The student should have prior experience with object oriented programming using either Java or C++

EE497: 3D Interface Technologies (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
3D Computer Graphics Mathematical fundamentals of 3D computer graphics: Manipulation of 2D & 3D data structures, Transformations, Vector Geometry, Matrix algebra. OpenGL ES / WebGL: Scene graphs, Transformations , Geometry, Appearance, Lighting, Texture mapping, Animation, Interaction.
Mobile Platforms for 3D Visualisation o The android platform, application development tools and concepts, application components, the manifest file, intents, the activity lifecycle, user interface components, event handling, layouts, fragments, data storage, interfacing with sensors (accelerometer, gyroscope, GPS, camera), 2D and 3D interfaces.
3D Display Systems Stereo visualisation: Shutter glasses, Autostereoscopic displays. Volumetric displays, Augmented reality, Sensor driven immersive 3D visualisation
3D Data Acquisition Medical Modalities: CT, MR, PET, SPECT, 3D Ultrasound. Industrial Systems: Contact approaches, Laser scanners, 3D Data formats
Volume Visualisation Indirect volume rendering: The marching cubes algorithm. Direct volume rendering: Image-order rendering: Maximum intensity projection, volume ray casting. Object-order rendering: Splatting. Hybrid approaches: Shear-warp factorisation. Optimisation techniques: Empty space skipping, early ray termination

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Development of a bespoke 3D application using an industry standard API.	1,3,6	10.00	Week 9
Assignment	Development of an Android based controller capable of manipulating 3D content.	1,2,3,4,6	15.00	Week 12

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	1,2,3,5	75.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE497: 3D Interface Technologies (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Weekly Lectures	36
Assignment Completion	Implementation time associated with completing the assignment	47
Independent Study	Preparation time for the assignment and the terminal exam	104.5
	Total Hours	187.50

This module has no Part Time workload.

Module Resources

This module does not have any book resources
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Robert Sadleir	75064669
Semester 2	Robert Sadleir	75064669
Autumn	Robert Sadleir	75064669

Module Teachers	
Staff Member	*Staff Email*
Robert Sadleir	Robert.Sadleir@dcu.ie

EE500: Network Performance

(Semester:1 Core)

Title:	Network Performance APPROVED
Long Title:	Network Performance
Language of Instruction:	English

Module Code:	EE500

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	28 programme(s)

Administrator:	Noel Murphy

Module Coordinator:	Gabriel-Miro Muntean

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The aim of the module is to introduce the students to advanced network performance concepts. The students will be reminded of the OSI and the TCP/IP models and basic network-related protocol aspects. They will be introduced to Quality of Service and Network Performance metrics as well as to Quality of Experience and Quality of Perception as metrics to assess the quality of data delivery. Various novel and existing network protocols at network and transport network layers will be introduced and their performance-related characteristics will be discussed. These protocols will be classified based on the layers of the OSI stack they operate at and include: IPv4, IPv6, TCP, SCTP, DCCP, RTP, RTCP, etc. At application layer, multimedia and gaming applications will be discussed in details in the context of real-time content delivery, but other application types will also be presented. Adaptive and non-adaptive content delivery solutions will be presented along with significant issues such as end-user perceived quality. Modeling and simulation with the goal of assessing network performance will be introduced with focus on the application layer. Java development with focus on performance of transport and application layer network protocols will be performed. Novel performance-related issues in the context of mobility, power consumption and security will be discussed.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	demonstrate advanced knowledge of networking in general and network performance in particular
LO2	define, compare and analyse network performance metrics, quality of service and quality of experience
LO3	present and comparatively assess different performance-aware communications solutions at network, transport and application network layers
LO4	analyse, contrast and compare solutions for power saving, mobility and security as well as for future network design and development
LO5	design and analyse solutions based on knowledge of modeling, simulations and prototyping

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE500: Network Performance

(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
1) Introduction Review of Layered Network Architectures; Introduction to Data Network Performance; Quality of Service (QoS), Quality of Experience (QoE) and Network Performance Metrics – definitions, relationship and mapping between them.
2) Quality of Service Metrics Availability, Delivery, Latency, Bandwidth, MTBF (Mean TimeBetween Failure), MTRS (Mean Time to Restore Service), Power consumption, Mobility, Quality of Service - Cause and Effect; Solutions for Improving Quality of Service levels.
3) Network Performance Metrics Availability (Connectivity, Functionality), Loss (One way loss, round trip loss), Delay (One way delay, Round trip time, Delay variance), and Utilization (Capacity, bandwidth, Throughput), Power consumption (Power per Mbps).
4) Network Modeling and Simulations Introduction to using NS-3; Measuring performance metrics – focus on performance at the application layer.
5) User Perceived Quality Type of services (Multimedia delivery, Real-time and interactive applications, Web applications, e-commerce, gaming) Quality of Experience and Quality of Perception.
6-7) Performance-aware Java Network Development Sockets; TCP and UDP Client-Server; Multi-threaded communication; Protocol Implementation: ICMP, SMTP, POP3, FTP and HTTP
8) Performance at Application Layer Multimedia delivery, Web applications, gaming, etc. Quality of Experience and Quality of Perception; Quality-aware application solutions: QOAS, LDA+, DOAS, iPAS
9) Performance at Network and Transport Layers Protocols: IPv4, IPv6, RTP, RTCP, SCTP, DCCP, MPTCP, TCP-SNOOP, Indirect-TCP, TCP-W
10) Mobility Aspects Mobility Management, network selection, handover, protocols to support mobility: Mobile IP, mDCCP, mSCTP, IEEE 802.21
11) Power Management and Network Security Issues Network power consumption; Energy savings solutions (e.g. IEEE 802.11 PSM); Authentication and authorisation, Cryptography, Security solutions (e.g. 802.11i)
12) Next Generation Networks Future networks design and development performance-related issues

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Application layer modeling/simulation/prototyping	1,3,5	25.00	n/a

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	n/a	1,2,3,4,5	75.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE500: Network Performance

(Semester:1 Core)

Module Workload

This module has no Full Time workload.

This module has no Part Time workload.

Module Resources

Essential Book Resources

Andrew S. Tanenbaum and David J. Wetherall 2013, *Computer Networks*, 5 Ed., Pearson [ISBN: 978-129202422]

Douglas E. Comer 2014, *Computer Networks and Internets*, 6 Ed., Pearson [ISBN: 978-013358793]

Douglas E. Comer 2013, *Internetworking with TCP/IP*, 2013 Ed., Pearson [ISBN: 978-013608530]

Afif Osseiran, Jose F. Monserrat and Patrick Marsch 2016, *5G Mobile and Wireless Communications Technology*, Cambridge University Press [ISBN: 978-110713009]

Erik Dahlman, Stefan Parkvall and Johan Skold 2016, *4G, LTE-Advanced Pro and The Road to 5G*, 3 Ed., Academic Press [ISBN: 978-012804575]

This module does not have any article/paper resources

This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
EEPM	MEng	1	Option
MEPM	MEng	1	Option
EEPM	MEng	1	Option
MEPM	MEng	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
CAPM	MSc	1	Option
CAPM	MSc	1	Option
CAPD	PhD	1	Option
MEPD	PhD	1	Option
EEPD	PhD	1	Option
MEPD	PhD	1	Option
CAPD	PhD	1	Option
EEPD	PhD	1	Option
CAPT	PhD-track	1	Option
MEPT	PhD-track	1	Option
EEPT	PhD-track	1	Option
MEPT	PhD-track	1	Option
CAPT	PhD-track	1	Option
EEPT	PhD-track	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Gabriel-Miro Muntean	80020216
Semester 2	Gabriel-Miro Muntean	80020216
Autumn	Gabriel-Miro Muntean	80020216

Module Teachers	
Staff Member	*Staff Email*
Gabriel-Miro Muntean	gabriel.muntean@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie

EE5001: Security for IoT Networks (Semester:1 Core)

Title:	Security for IoT Networks DRAFT
Long Title:	Security of IoT Networks
Language of Instruction:	English

Module Code:	EE5001

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

moduleLearningOutcomeTaxonomy:	Blooms

Module Delivered In	no programmes

Administrator:	Jennifer Bruton

Module Coordinator:	Xiaojun Wang

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	This module will introduce students to the areas of cryptography and cryptanalysis for IoT networks. It will provide an understanding of the algorithms used to protect IoT networks and the design choices behind the algorithms chosen. The student will develop a workable knowledge of the mathematics used in cryptology and this will allow them to understand attacks on cryptosystems to prevent future attacks. Other technologies covered will include privacy protection, trusted hardware, public key infrastructure (PKI), PKI-based authentication, programmable logic, hardware encryption/decryption.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Understand the hierarchical structure of the IoT network and security issues at each network layer. Familiar with Internet security architecture.
LO2	Understand the security threats of the IoT network. Comprehensively explain the range of algorithms used to secure IoT networks and the design criteria to be used in choosing algorithms.
LO3	Demonstrate a working knowledge of the mathematics used in cryptology, allowing them to understand attacks on cryptosystems and how to prevent future attacks.
LO4	Be able to implement appropriate cryptographic algorithm in either hardware or software for specific use cases.
LO5	Be able to critically analyse and evaluate the performance and vulnerability of crypto algorithms and IoT security systems.

moduleLearningOutcomeTaxonomy: Blooms					
#	**LO1**	**LO2**	**LO3**	**LO4**	**LO5**
C1			Y		
C2	Y	Y			
C3				Y	
C4			Y		Y
C5			Y	Y	
C6					Y
P1					
P2					
P3					
P4					
P5					
P6					
P7					
A1					
A2					
A3					
A4					
A5					

moduleLearningOutcomeTaxonomy Reference: Blooms		
#	**Taxonomy Description**	**Taxonomy Group**
C1	Knowledge	Cognitive
C2	Comprehension	Cognitive
C3	Application	Cognitive
C4	Analysis	Cognitive
C5	Synthesis	Cognitive
C6	Evaluation	Cognitive
P1	Perception	Psychomotor (Technical Skills)
P2	Set	Psychomotor (Technical Skills)
P3	Guided Response	Psychomotor (Technical Skills)
P4	Mechanism	Psychomotor (Technical Skills)
P5	Complex Overt Response	Psychomotor (Technical Skills)
P6	Adaptation	Psychomotor (Technical Skills)
P7	Origination	Psychomotor (Technical Skills)
A1	Receiving to Phenomena	Affective (Humanities)
A2	Responding to Phenomena	Affective (Humanities)
A3	Valuing	Affective (Humanities)
A4	Organizing Values	Affective (Humanities)
A5	Internalizing Values	Affective (Humanities)

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
An ability to program in Python (or any other programming language) is required for the assignments. Students who select this module should have a good mathematical aptitude. The module will cover some of the theory underpinning modern cryptography (including prime numbers, modular arithmetic, discrete logarithms, finite fields and polynomial arithmetic), which is required to understand the cryptographic algorithms.

EE5001: Security for IoT Networks (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Introduction to IoT and Information Security Understand the concepts and characteristics of IoT, understand the architecture security threats of IoT, familiar with the main means for ensuring IoT.
Security System of IoT Understand the hierarchical structure of IoT and security issues at all levels Introduction to the security architecture of the Internet, Perception layer security, Network layer security and Application layer security, information security and privacy protection in the Cloud.
Data Security Mathematics used in cryptology, pseudorandom number generators, Stream cypher and block cypher, DES, Triple DES, AES, algorithms, block cypher mode of operation, RSA algorithm, key management, hash function and message digest, digital signature, lightweight encryption algorithms for IoT.
Privacy and Security The connection and difference between privacy security and information security, personal information privacy protection, data sharing privacy protection methods.
Access Security IoT access security, trust management, identity authentication, access control, public key infrastructure
System Security Understand the concept of network and system security, malicious attacks, intrusion detection and prevention, firewall principles, the principle of virus cleaning, network security protocols.
Wireless Network Security Wireless network security threats, WiFi security technology, ZigBee security technology, Bluetooth security technology.

Assessment Breakdown	%
Continuous Assessment	50.00%
End of Academic Session	50.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Report(s)	Review the architecture of secure IoT networks	1,3	15.00	Week 5
Presentation	Presentation of Project	3,4	10.00	Week 11
Project	Review report of lightweight cryptography for IoT, implementation of AES and PRESENT	2,3,4,5	25.00	Week 10

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Examination	1,2,3,5	50.00	End-of-Semester

Reassessment Pre-Requisite
Repeat examination *Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.*
Reassessment Description Reassessment is available for both CA and exam.

DCU reserves the right to alter the nature and timings of assessment

EE5001: Security for IoT Networks (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Assignment Completion	No Description	30
Independent Study	No Description	122
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
William Stallings 2019, *Cryptography and Network Security Pearson Etext Access Card*, 8th Edition Ed., Pearson [ISBN: 9780135764039]
Supplementary / Recommended Book Resources
Niels Ferguson, Bruce Schneier and Tadayoshi Kohno 2011, *Cryptography Engineering: Design Principles and Practical Applications*, Wiley [ISBN: 0470474246] **Jean-Philippe Aumasson 2017, *Serious Cryptography: A Practical Introduction to Modern Encryption*, No Starch Press [ISBN: 1593278268]**
This module does not have any article/paper resources
Other Resources
eBook: 2020*IoT Security: Advances in Authentication*, John Wiley & Sons Ltd https://onlinelibrary.wiley.com/doi/book /10.1002/9781119527978

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Xiaojun Wang	75020688
Semester 2	Xiaojun Wang	75020688
Autumn	Xiaojun Wang	75020688

Module Teachers	
Staff Member	*Staff Email*
Xiaojun Wang	Xiaojun.Wang@dcu.ie

EE506: Photonic Devices (Semester:1 Core)

Title:	Photonic Devices APPROVED
Long Title:	Photonic Devices
Language of Instruction:	English

Module Code:	EE506

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	19 programme(s)

Administrator:	Noel Murphy

Module Coordinator:	Pascal Landais

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The use of semiconductor devices in optical communications and the recent development in semiconductor materials have brought up the need to understand the technology of these components. This module aims to equip students with a deep understanding of the science of these devices and their integration in optical communication networks.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	select semiconductor materials for light emission and detection applications based on an understanding of photoemission photoabsorption and band structure.
LO2	be capable of solving various problems related to light emitting and light detecting device designs.
LO3	mathematically analyse various types of semiconductor lasers and detectors.
LO4	identify key principles of optical communication devices.
LO5	identify and distinguish various optical data processing schemes.
LO6	identifiy growth and processing technologies for light emitter and detector fabrication
LO7	analyse the propagation of an electromagnetic wave in free space, at a media interfaces, and in various guides.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE506: Photonic Devices
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Duality of light Description of light as an electromagnetic wave. Introduction from Maxwell's equation to Helmholtz's equation. Limitation of the electromagnetic approach, introduction of the quantum aspect of light. Definition of photon.
Interaction light matter Derivation of Einstein's coefficent. Conditions for light emission or detection.Optical properties of semiconductors materials, definition of band-gap direct or indirect and their use for light emission and detection.
Physics of semiconductor devices Features of various types of light-emitting diode, lasers and semiconductor amplifiers. Overview of LED/LASER manufacturing. Physics of double hetero-junction lasers: their simulation based on rate-equation in time and frequency domains, noise origin and simulation. Physics of light detectors, photodiode and avalanche photodiode, sensitivity, response time, wavelength selection using optical filters, bandwidth and insertion loss of optical filters.
Use of semiconductor lasers for telecommunications Short pulse generation by Q-switching and passive or active mode-locking schemes. Physics of external modulators. All optical function generated by semiconductor lasers, wavelength cobnversion, and clock recovery for instance. Applications of semiconductor devices in OTDM or WDM.
Semiconductor material Overview of active materials bulk, quantum well, wire dot and quatum dot. description of photonics band-gap materials

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Performance evaluation	Series of questions to be solved	1,2,3,4,5,6	25.00	

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	1,2,3,4,5,6,7	75.00	End-of-Semester

Reassessment Pre-Requisite

Repeat examination
Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.

DCU reserves the right to alter the nature and timings of assessment

EE506: Photonic Devices
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Independent Study	No Description	151
	Total Hours	187.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
G.P. Agrawal and N.K. Dutta, *Long wavelength semiconductor laser*, van Nostrand Ed. **J. Wilson and J. Hawkes, *Optoelectronics an introduction*, Prentice Hall Ed.** **Midwinter, J.E, *Opto Electronics and Lightwave Technology*, Wiley Ed.** **Saleh, B.E. & Teich, M., *Fundamentals of Photonics*, Wiley Ed.**
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
MEPM	MEng	1	Option
EEPM	MEng	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
CAPM	MSc	1	Option
EEPD	PhD	1	Option
MEPD	PhD	1	Option
CAPD	PhD	1	Option
EEPT	PhD-track	1	Option
MEPT	PhD-track	1	Option
CAPT	PhD-track	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Pascal Landais	75066874
Semester 2	Pascal Landais	75066874
Autumn	Pascal Landais	75066874

Module Teachers	
Staff Member	*Staff Email*
Pascal Landais	pascal.landais@dcu.ie

EE507: Entrepreneurship for Engineers (Semester:1 Core)

Title:	Entrepreneurship for Engineers APPROVED
Long Title:	Entrepreneurship for Engineers
Language of Instruction:	English

Module Code:	EE507

Credits:	7.5

NFQ Level:	9

Field of Study:	Environmental Science

Module Delivered In	19 programme(s)

Administrator:	Noel Murphy

Module Coordinator:	Derek Molloy

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To introduce students to key concepts in entrepreneurship and technological innovation Give students an understanding of the challenges involved in creating and working in a new venture. Provide students with basic skills in important aspects of business organization and management

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Assess commercial opportunities and develop appropriate business plans
LO2	Analyse the commercial potential of a technological innovation
LO3	Articulate and appraise the challenges of commercializing technology
LO4	Experience of a pilot-scale business planning
LO5	Plan for of the organizational, commercial, and financial components of a successful technology business

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE507: Entrepreneurship for Engineers
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
New Venture Creation Introduction & The Technologist's PerspectiveEntrepreneurial Technologists - Your Role in the Process, Innovation & IdeasIdentifying a Commercial Opportunity & Market ResearchThe Elements of a Successful VentureDeveloping, Producing and Matketing a ProductProtecting your Intellectual PropertyPeople: Building the Business TeamFinancing: Your Research and the VentureBusiness PlanningInternational Markets & Growth

Assessment Breakdown	%
Continuous Assessment	50.00%
End of Academic Session	50.00%

Continuous Assessment				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Business / Technology Commercialisation plan	1,2,3,4,5	50.00	

End of Module Formal Examination				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	1,2,3,4,5	50.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE507: Entrepreneurship for Engineers
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Independent Study	reading assignments and project	151
	Total Hours	187.00

This module has no Part Time workload.

Module Resources

Essential Book Resources

Kathleen R. Allen. 2007, *Growing and managing a small business : an entrepreneurial perspective,*, Boston, MA : Houghton Mifflin Co.

Garavan, T.N., O Cinneide, B., Fleming, P. 1997, *Entrepreneurship & Business Start Ups in Ireland volume 1: An Overview*, Oak Tree Press

David Deakins, *Entrepreneurship and Small Firms*, McGraw Hill Higher Education [ISBN: 9780077121624]

Supplementary / Recommended Book Resources

Garavan, T.N., O Cinneide, B., Garavan, M., Hynes, B., Walsh, F. 1997, *Entrepreneurship & Business Start Ups in Ireland volume 2* , Oak Tree Press

Travers, J. 2001, *Driving the Tiger: Irish Enterprise Spirit*, Gill and Macmillan

Drucker, P 2001, *Innovation and Entrepreneurship*, Butterworth Heinemann

This module does not have any article/paper resources

This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
MEPM	MEng	1	Option
EEPM	MEng	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
CAPM	MSc	1	Option
EEPD	PhD	1	Option
MEPD	PhD	1	Option
CAPD	PhD	1	Option
EEPT	PhD-track	1	Option
MEPT	PhD-track	1	Option
CAPT	PhD-track	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Stephen Daniels	80005527
Semester 2	Stephen Daniels	80005527
Autumn	Stephen Daniels	80005527

Module Teachers	
Staff Member	*Staff Email*
Stephen Daniels	stephen.daniels@dcu.ie

EE508: Device Manufacturing

(Semester:1 Core)

Title:	Device Manufacturing APPROVED
Long Title:	Fundamentals of Device Manufacturing
Language of Instruction:	English

Module Code:	EE508

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Paul Ahern

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Module Motivation: This module will enable the student to develop an understanding of device fabrication as it relates to optical, microelectronic, sensors, and other miniaturised devices. The major enabling manufacturing technologies will be analysed as will process flow, integration, design aspects, and statistical methods in manufacturing .

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Design and analyse the processes involved in micro/nano systems manufacture
LO2	Calculate important features and limitations of micro and nano system design
LO3	Analyse the performance of a tool-set and relate to productivity and yield
LO4	Design device manufacturing process flows
LO5	Conduct the required background research related to the module topic and be able to identify opportunities for further technology development
LO6	Write well structured reports which are written to the correct level of technical detail to suit the intended reader

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE508: Device Manufacturing

(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Yield Engineering Functional and parametric yield estimation, equipment issues
Metrology and Control Tool control and monitoring, integration with factory information systems, statistical and advanced process control
Miniaturisation Moore's Law, design rules, design for manufacture, basic VLSI circuits
Manufacturing Technologies Lithography, Etch and Deposition, Planarisation, Laser Processing

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	The student will critically review the state of the art for a particular technology related to device manufacturing and develop a road-map for advancement.	1,2,5,6	25.00	Once per semester

End of Module Formal Examination				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	1,2,3,4	75.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE508: Device Manufacturing

(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Lectures	36
Independent Study	Assignment Research & Delivery	50
Independent Study	Self-directed study of materials and study for the examination.	102
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Gary S. May, Costas J. Spanos, *Fundamentals of semiconductor manufacturing and process control*, IEEE ; c2006. [Piscataway] [ISBN: 9780471784067]
This module does not have any article/paper resources
Other Resources
Website: *Module Loop Website* http://loop.dcu.ie

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Paul Ahern	80358559
Semester 2	Paul Ahern	80358559
Autumn	Paul Ahern	80358559

Module Teachers	
Staff Member	*Staff Email*
Stephen Daniels	stephen.daniels@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Paul Ahern	Paul.Ahern@dcu.ie

EE509: Data Network Protocol Analysis & Simulation (Semester:1 Core)

Title:	Data Network Protocol Analysis & Simulation APPROVED
Long Title:	Data Network Protocol Analysis & Simulation

Module Code:	EE509

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	10 programme(s)

Administrator:	Noel Murphy

Module Coordinator:	Jennifer McManis

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The ability to predict how a data communications network will perform in terms of delay, throughput or packet loss is an important aspect of the engineering practice of computer and telecommunications network design. Given the complexity of operation of communications protocols, coupled with the randomness of data traffic transported by a network, gaining a reliable estimate of system performance requires careful analysis with appropriate modelling techniques. The aim of this module is to firstly review the operating principles of data communications protocols and then to develop the basic theory and practice required for evaluating the performance of communications systems and data networks, using discrete-state mathematical and computer simulation modelling methods.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe the basic operating principles of the protocols used to implement various layers of the OSI model and identify their basic performance parameters,
LO2	design and implement a disrcete-event computer simulation model for performance evaluation of a data communications network and be able to analyse the simulation output using statistical methods,
LO3	derive results relating to single server queuing models and networks of queues,
LO4	apply the analytic techniques of probability and queuing theory to calculate the performance characteristics of selected communications systems or protocols,
LO5	compare the achievable accuracy of the results from simulation models to that of analytic models that employ approximations to achieve a tractable solution.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
none

EE509: Data Network Protocol Analysis & Simulation (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Review of Data Network Protocols and Introduction to Performance Evaluation Network layer functions and an intrduction to circuit and packet switching, link layer protocols, IP, routing, TCP, and application protocols. Future network trends. Motivation for the use of analysis and simulation methods: performance measures, resource allocation/dimensioning, deployment costs.
Mathematical Fundamentals for Performance Analysis Probability spaces, probability functions, random variables, probability laws, stochastic processes, renewal processes, Poisson process, Markov processes and Birth-Death processes.
Discrete-Event Stochastic Simulation Methods Introduction to simulation modelling methodologies, random variates, pseudo-random number generators, non-uniform variates: inverse transform sampling and rejection sampling, event-lists, event scheduling and implementation, simulation validation, confidence intervals, and analysis of results.
Queueing Analysis Methods Performance measures and objectives, Kendall's notation, Little's law, Markovian queueing systems, M/M/1, M/M/infinity, M/M/n, M/M/1/K, M/M/m/m, priority queues, the M/G/1 and M/D/1 queue. Product-Form Queueing networks.
Analysis of Network Protocol Performance Examples such as LAN/MAN random access and polling networks, packet switched network throughput, and router queue management.

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Project	simulation assigment	2	17.00	Week 9
Project	analysis assignment	5	8.00	Week 12

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	5	75.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE509: Data Network Protocol Analysis & Simulation (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Assignment Completion	For the simulation assignment you will write your own basic discrete event simulator. Java is the supported language, but it is possible to complete the assignment in another language such as C or C++.	40
Directed learning	No Description	3
Independent Study	No Description	109
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
James Kurose and Keith Ross 2017, *Computer Networking: A Top-Down Approach*, 2017 Ed., Addison Wesley [ISBN: ISBN-13: 9780] **Harry Perros, *Computer Simulation Techniques--The Definitive Introduction*, http://www4.ncsu.edu/~hp/books.html** **Analysis of Computer Networks 2015, *Analysis of Computer Networks*, Springer [ISBN: 978-3-319-156]**
Supplementary / Recommended Book Resources
Kishor Trivedi 2002, *Probability and Statistics with Reliability, Queuing, and Computer Science Applications*, 2 Ed., Wiley-Interscience [ISBN: 0471333417]
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Jennifer McManis	75034956
Semester 2	Jennifer McManis	75034956
Autumn	Jennifer McManis	75034956

Module Teachers	
Staff Member	*Staff Email*
Jennifer McManis	Jennifer.McManis@dcu.ie

EE513: Connected Embedded Systems (Semester:1 Core)

Title:	Connected Embedded Systems APPROVED
Long Title:	Connected Embedded Systems
Language of Instruction:	English

Module Code:	EE513

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Derek Molloy

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Connected embedded systems are the building blocks of the Internet of Things (IoT). Connected refers to the fact that the systems interface to the real world via sensors and actuators, and also that the embedded systems can communicate to one another and to cloud-based Platform-as-a-Service (PaaS) solutions. This module exposes students to state-of-art research and solutions for such embedded systems, including: embedded Linux, multi-platform SoC solutions, real-time interfacing, telemetry protocols for IoT, and messaging.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe current state-of-art research and solutions for connected embedded systems
LO2	Design embedded systems that utilize full-stack mainline Linux, appreciating the strengths and weaknesses of OS-based embedded solutions
LO3	Interface embedded systems to the real world using a variety of sensors and actuation hardware, and write high-level program code that wraps low-level sensor interfaces
LO4	Evaluate state-of-art real-time approaches (e.g., SoC-based) and research for embedded applications that require determinism, and to appreciate real-time constraints on the communication required for interconnected embedded systems
LO5	Identify and research an appropriate communications framework to suit a specific connected embedded application
LO6	Develop a distributed locally-connected multi-processor system using wired and/or wireless network topologies and communications
LO7	Build full stack IoT solutions (real-world interfacing to cloud-based platform-as-a-service (PaaS) solutions) and document the processes and design detail involved

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
Ideally students taking this module will have a good understanding of object-oriented programming languages such as C++/Java. It is highly recommended (but not required) that students take the "EE402: OOP with Embedded Systems" module.

EE513: Connected Embedded Systems (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
A Networked Future The module begins with a big-picture introduction to the Internet of Things (IoT) that describes technology, services and frameworks. Opportunities and challenges are described along with discussions on emerging technologies as they relate to applications such as the environment, biomedicine, consumer electronics, defence, and communications. Other topics related to embedded devices include the: Internet of Industrial Things, Internet of Tiny Things, and the Internet of Nano Things.
Embedded Linux Linux on an embedded system, including topics such as: bootloaders; Git; managing Linux systems; systemd, and, real-time limitations of OS-based embedded devices. The Embedded Linux OS is used as a practical platform for this module, allowing for the application of the concepts to be applied in practical assignments.
Interfacing to the Real-World Programming on embedded devices using high-level languages. The conflict between OS and non-OS (bare metal) coding. Interfacing to the real world using embedded Linux, which includes the use of electronics for sensing and actuation. Brief discussion on interfacing electronics via ADC, SPI, I2C, CAN bus, and UART devices. Cross-platform development in C/C++, and wrapping low-level devices with high-level OOP constructs. Linux kernel programming is described, including a discussion on user-space versus kernel-space coding.
Real-Time Embedded Systems Principals of real-time operating systems, including: software architectures for real-time embedded, multicore processors, RTOS, Real-Time Scheduling, Resource Sharing, Message Queueing and Inter-task Signalling and Communication. FPGA solutions and microkernel-based QNX Oss are also discussed. System on a Chip (SoC) based real-time acceleration and the challenges of multi-platform integration are investigated.
Communicating with Embedded Systems Frameworks for messaging with distributed embedded systems are discussed, including historical and current solutions. Other topics include: Ad-hoc communication; Machine-to-machine communication and autonomy; and, telemetry protocols for IoT (including MQTT, CoAP, XMPP).
Local Distributed Embedded Wired and wireless network topologies for local distributed embedded applications (e.g., Ethernet, CAN bus, RFID, ZigBee, Wi-Fi, Bluetooth) are described. Other topics include: communication efficiency; frameworks for service processor integration; messaging passing interfaces (MPIs) and XML/JSON; data aggregation; embedded data storage; and, Rete algorithm rules engines.
Internet Connected Embedded This section describes a detailed coverage of the concepts involved in an Internet distributed connected embedded system, such as: device management, key management, debugging, triggers, listeners, alarms, design for failure (e.g., Last Will and Testament (LWT)). Platform-as-a-Service (PaaS) solutions such as ThingSpeak, Amazon AWS IoT, IBM BlueMix IoT are examined, and one such PaaS is utilized in the second assignment.

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Interfacing Embedded Systems to the Real World: Students are required to develop a self-contained embedded system that interfaces to the real world using electronic sensors. High-level software must be written to wrap the low-level interface.	2,3,4	10.00	Week 6
Assignment	Internet Connected Embedded: In this assignment students must develop a full-stack IoT solution that interfaces to a high-end Platform as a Service (PaaS). There is a significant reporting element to this assignment.	2,5,6,7	15.00	Week 12

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End of Academic Session written examination	1,2,3,4,5,6	75.00	End-of-Semester

Reassessment Pre-Requisite

Repeat examination
Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.

DCU reserves the right to alter the nature and timings of assessment

EE513: Connected Embedded Systems (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Classroom Lectures	36
Independent Study	Study of the on-line tutorials, self-directed research and study of the materials.	87
Independent Study	Exam study	20
Independent Study	Completion of Assignment work	45
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Derek Molloy 2014, *Exploring BeagleBone: Tools and Techniques for Building with Embedded Linux*, 1 Ed., Wiley New York [ISBN: 978-111893512] **Derek Molloy 2016, *Exploring Raspberry Pi: Interfacing to the Real-World with Embedded Linux*, 1 Ed., Wiley New York [ISBN: 978-111918868]**
This module does not have any article/paper resources
Other Resources
Website: Derek Molloy 2016, *Course Notes Website*, DCU http://ee5IOT.eeng.dcu.ie

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Derek Molloy	75027429
Semester 2	Derek Molloy	75027429
Autumn	Derek Molloy	75027429

Module Teachers	
Staff Member	*Staff Email*
Derek Molloy	Derek.Molloy@dcu.ie

EE514: Data Analysis and Machine Learning (Semester:1 Core)

Title:	Data Analysis and Machine Learning APPROVED
Long Title:	Data Analytics and Machine Learning
Language of Instruction:	English

Module Code:	EE514

Credits:	7.5

NFQ Level:	9

Field of Study:	Artificial Intelligence & Signal & Image Processing

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Kevin McGuinness

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	This module will provide students with fundamental and advanced skills required for data analytics, including: data management, processing, summarization, and predictive analytics. It is focused on providing students with a strong theoretical foundation, along with the ability to make practical use of the advanced techniques in the field. The Python programming language will be used for demonstrating the use of various techniques throughout the module, giving students practical tools for solving relatively sophisticated and broadly-defined real world problems in a well-established and widely-used programming environment.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	describe several widely used methods for data storage, including specialized file formats, SQL and NoSQL databases, and key-value stores
LO2	explore datasets using summary statistics, statistical plots, and advanced data visualization methods (e.g. t-SNE)
LO3	describe supervised machine learning theory, including problem types, best practices for data preparation, model selection, overfitting and underfitting, and bias-variance tradeoff
LO4	apply fundamental and advanced classification and regression algorithms including: linear and nonlinear regression, discriminant analysis, decision trees, logistic regression, support vector machines, and ensembles
LO5	perform various types of generic unsupervised data analytics including cluster analysis, density estimation, and dimensionality reduction
LO6	describe the principles of modern representation learning and deep learning techniques and evaluate the merits of several state-of-the-art models
LO7	demonstrate a critical appreciation of available software packages for data analysis
LO8	demonstrate the ability to implement a predictive analytics pipeline

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
Undergraduate level programming experience in a procedural, functional, or OO language. Intermediate linear algebra and multi-variate calculus. A first course in statistics.

EE514: Data Analysis and Machine Learning (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Introduction to Python Programming for Data Analytics Introduce students unfamiliar with Python to the syntax and structure of the language, with a particular focus on working with data in various forms. This will involve introducing some of the standard numeric and scientific computing libraries available in Python and demonstrating how these can be used to perform several standard tasks including reading and writing data in standard formats, data types, slicing and shaping data, and performing standard manipulation tasks.
Data Summarization and Visualization Discuss various types of univariate (mean, median, variance, stddev, quantiles, mode, etc.) and bivariate (covariance, Pearson and Spearman correlation) statistics and how they can be used to summarize data. Illustrate several ways of visualizing single and multi-dimensional data, including basic plots (scatter, line, bar, contour, image), statistical plots (e.g. histogram, density plot, box plots, violin plots, and error bars), and advanced visualization techniques (e.g. t-SNE). Tufte's principles for the visual display of quantitative information will be used to demonstrate best practices.
Unsupervised Machine Learning Discussion of the goals of unsupervised learning with examples including the types of objectives used in practice. This will include an in-depth discussion of several standard methods for clustering (k-means, hierarchical clustering, linkage types), and an overview of latent variable models and Principal Component Analysis (PCA). Students will also be expected to learn on how to use these models in practice with standard and advanced software tools and applications.
Supervised Machine Learning Principles Overview and objectives of supervised learning. Introduction to standard notation and conventions, problem types (regression, classification, structured prediction), training and tests sets, black box learning principles, training error, test error, generalization error, and out-of-sample error. Discussion of bias-variance tradeoff, overfitting and underfitting, the no free lunch theorem, model selection, cross-validation, data hygiene, and data snooping.
Supervised Machine Learning Algorithms Discussion of several important classes of machine learning algorithms including linear regression, decision trees, ensemble methods, logistic regression, support vector machines, and a range of neural network types. Algorithm for optimizing loss functions (gradient descent and stochastic gradient descent). Types of loss functions (convex and non-convex). Kernel methods.
Representation Learning and Deep Learning Principles of representation learning. Introduction to multi-layer perceptrons, stacked autoencoders, convolutional neural networks, and recurrent neural networks. Practical optimization methods, GPU-based optimization, and software packages. Illustration of several real-world applications (natural language processing, image classification, speech recognition, information retrieval, recommender systems). Comparative discussion of several industry standard technologies (Tensorflow, Caffe, Torch).

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Students will be provided with a labelled dataset in a standard format (e.g. HDF5). Their task will be to divide the data into training and validation sets, perform some appropriate transformations of the data, and implement a functional classification pipeline. A second test dataset will also be provided, but without labels. Students will submit their code, a report, and the predictions of their classification pipeline on the unlabelled test dataset. Assessment will consist of computing the accuracy of their solution on the test data as well as grading their report and code.	1,2,3,4,7,8	25.00	Week 7

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	n/a	1,2,3,4,5,6,7,8	75.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE514: Data Analysis and Machine Learning (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Classroom Lectures	36
Independent Study	Regular Homeworks	24
Independent Study	Assignment Work	36
Independent Study	Self-directed study of materials and study for the examination.	92
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources

Trevor Hastie, Robert Tibshirani, Jerome Friedman 2009, *The elements of statistical learning*, Springer New York, N.Y. [ISBN: 9780387848570]

Supplementary / Recommended Book Resources

Yaser S. Abu-Mostafa, Malik Magdon-Ismail, Hsuan-Tien Lin, *Learning From Data*, AMLBook [ISBN: 1600490069]

Edward R. Tufte 2001, *The visual display of quantitative information*, Graphics Press Cheshire, Conn. [ISBN: 0961392142]

Mark Pilgrim, *Dive Into Python*, Apress [ISBN: 1590593561]

Wes McKinney, *Python for Data Analysis*, O'Reilly Media [ISBN: 1449319793]

***Machine Learning in Python: Essential Techniques for Predictive Analysis*, Chichester; John Wiley & Sons [ISBN: 1118961749]**

This module does not have any article/paper resources

Other Resources

Website: *Scikit-learn: Machine Learning in Python*
http://scikit-learn.org/stable/

Website: *Pandas: Python Data Analysis Library*
http://pandas.pydata.org/

Website: *Seaborn: Statistical Data Visualization*
http://stanford.edu/~mwaskom/software/se aborn/

Website: *TensorFlow: Open Source Software Library for Machine Intelligence*
https://www.tensorflow.org/

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Kevin McGuinness	80036392
Semester 2	Kevin McGuinness	80036392
Autumn	Kevin McGuinness	80036392

Module Teachers	
Staff Member	*Staff Email*
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Kevin McGuinness	kevin.mcguinness@dcu.ie

EE515: Real-Time Digital Signal Processing (DSP) (Semester:1 Core)

Title:	Real-Time Digital Signal Processing (DSP) APPROVED
Long Title:	Real-Time Digital Signal Processing
Language of Instruction:	English

Module Code:	EE515

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Prince Anandarajah

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	This module will provide students with the knowledge, skills and competencies in the area of high-speed DSP. It is focused on providing students with not only a strong theoretical foundation, but also the ability to make practical use of modern DSP approaches.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Demonstrate a mastery and detailed appreciation of the theoretical founding principles, central algorithms and current implementation-focussed technology of DSP.
LO2	Categorize the different classes of problems in DSP, and to decide upon appropriate methodologies and technologies for their solution.
LO3	Design and implement algorithmic solutions for solving advanced DSP problems.
LO4	Design and implement DSP algorithms for real-time applications.
LO5	Establish and categorize hardware/software boundaries in DSP
LO6	Define embedded systems with consideration to cost, power, accuracy and other constraints.
LO7	Conduct literature searches, abstract and summarize relevant ideas and techniques in DSP- related areas, and demonstrate scientific report writing to as Masters level.
LO8	Demonstrate the use of analysis and presentation packages relevant to DSP.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE515: Real-Time Digital Signal Processing (DSP) (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
A review of DSP fundamentals ADC, DACs, Nyquist criteria, Aliasing; Fixed point and floating point number representations; Time-domain and Frequency-domain representation of discrete-time signals, Linear time-invariant systems in the transform domain, Transfer functions; Convolution, Correlation, Windowing operations; Applications of DSP, Low cost DSP, Power efficient DSP, High performance DSP.
Quadrature and multi-rate signal processing The Hilbert transform; waveform modulation; waveform detection/demodulation; envelope detection and rectification; quadrature frequency translation; decimation; interpolation; base-band sampling; IF and under sampling, frequency shift and recovery.
Real-time Systems: Real-time systems (soft and hard real time systems, differences between real time and time shared systems, real time event characteristics) Efficient execution (resource management), Challenges in real time systems, Distributed and multiprocessor architectures, Embedded systems.
Embedded Systems and DSP: Introduction to embedded systems, hardware gates, software programmable, general purpose processors, microcontrollers, FPGA enabled solutions
Hardware for DSP FPGA in embedded design, ASICs vs FPGAs, Software programmable DSP, General purpose embedded cores; Accuracy vs complexity
DSP Programmable Architectures (DSPPA): Common features of DSPPA (DSP core and Instruction Set Architecture features, Memory architecture (access sizes and alignment issues), data operations.
Case Studies Examples include: DSP for IoT, DSP for SDR, LTE baseband software design, MIMO systems, Beamforming for WIMAX

Assessment Breakdown	%
Continuous Assessment	30.00%
End of Academic Session	70.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Design of a DSP chain based on featured content and/or case studies.	1,2,3,4	15.00	Once per semester
Report(s)	Detailed report writing on the applications of DSP processes in selected industry fields.	1,5,7	15.00	Once per semester

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End of Semester Examination	1,2,3,4,5,6,8	70.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE515: Real-Time Digital Signal Processing (DSP) (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Lectures	36
Assignment Completion	Assignment 1	30
Assignment Completion	Assignment 2	30
Independent Study	Study of module materials and assessment preparation	92
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Robert Oshana 2012, *DSP for Embedded and Real-Time Systems*, 1st Ed., Newnes [ISBN: 978-012386535]
This module does not have any article/paper resources
Other Resources
Website: *Module Loop Website* http://loop.dcu.ie

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Prince Anandarajah	80014151
Semester 2	Prince Anandarajah	80014151
Autumn	Prince Anandarajah	80014151

Module Teachers	
Staff Member	*Staff Email*
Prince Anandarajah	Prince.Anandarajah@dcu.ie

EE516I: Blockchain Scalability
(Semester:1 Core)

Title:	Blockchain Scalability APPROVED
Long Title:	Blockchain Scalability
Language of Instruction:	English

Module Code:	EE516I

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Jennifer Bruton

Module Coordinator:	Martin Collier

moduledepartment:	40 - COMPUTING

Module Description:	This module will give students a knowledge of many of the technologies which underpin distributed ledger implementations and smart contract architectures, and how they scale. Various implementation approaches and acceleration techniques will be explored, and their energy cost and throughput will be evaluated as a function of ledger size and transaction rate. The resources needed to compromise the ledger or subvert the contract will also be explored for various existing and proposed distributed ledger, smart contract and blockchain approaches.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Explain the operation of peer to peer networks and the associated resource discovery algorithms
LO2	Critically evaluate the scaling properties of such networks.
LO3	Compare various distributed trust and consensus algorithms and their scaling properties from a cost and vulnerability perspective.
LO4	Critically evaluate methods for achieving consensus (e.g., blockchain mining), identifying the benefits of various architectures and acceleration techniques, and the energy cost of each method.
LO5	Critically evaluate methods of establishing trust including Proofs such as Proof of Stake, and to select among the alternatives based on considerations of scale and energy cost.
LO6	Identify the elements in any smart contract architecture which require stakeholder trust, and critically evaluate how their vulnerability scales with network size.
LO7	Analyse the transaction rates achievable in various smart contract and cryptocurrency architectures.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE516I: Blockchain Scalability
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Peer to peer networks An assessment of architectures, protocols and algorithms to support distributed computing and data processing where all parties are peers.
Distributed trust from a scalability perspective A review of a number of algorithms used or proposed for blockchain, smart contract and related applications requiring distributed trust will be undertaken. For each algorithm, the impact of increasing the number of participants on the aggregate computational load and the achievable transaction rate will be assessed.
Proof of Stake and alternatives Numerical evaluation of the computational and energy cost of implementing Proof of Work, using a range of acceleration techniques. Investigation of alternatives to Proof of Work using the same criteria, so that the appropriate algorithm for given blockchain or other distributed trust applications can be selected.
Distributed Trust and Smart Contracts Explore the robustness of various architectures for implementing distributed trust and smart contracts, considering how increased network size affects the architecture's vulnerability to malicious actors. The tradeoffs between computational load and vulnerability will be determined for all approaches.
Use case exploration Combine the elements above to identify a suitable architecture and set of algorithms for a specific use case.

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Extended Essay / Dissertation	Students will be asked to devise a blockchain architecture to address a specific use case, Solution to include justifications for all software elements, algorithms and hardware used, justifying any energy costs and transaction rates predicted for the architecture	2,3,5,6,7	25.00	Week 8

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	n/a	1,2,3,4,5,6,7	75.00	End-of-Semester

Reassessment Pre-Requisite

Repeat examination
Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.

DCU reserves the right to alter the nature and timings of assessment

EE516I: Blockchain Scalability
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Assignment Completion	No Description	30
Independent Study	No Description	122
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources

Imran Bashir, *Mastering Blockchain: Distributed ledger technology, decentralization, and smart contracts explained*, 2nd Ed., Packt [ISBN: 1788839048]

Sachin Shetty, Charles A. Kamhoua, Laurent Njilla (Editors) 2019, *Blockchain for Distributed Systems Security*, 1st ed. Ed., Wiley [ISBN: 1119519608]

Supplementary / Recommended Book Resources

Roger Wattenhofer, *Distributed Ledger Technology: The Science of the Blockchain*, Amazon Kindle

Essential Article/Paper Resources

Hyperledger Performance and Scale Working Group *Hyperledger Blockchain Performance Metrics*
https://www.hyperledger.org/resources/publications/blockchain-performance-metric s

Konstantinos Christidis & Michael Devetsikiotis 2016, *Blockchains and Smart Contracts for the Internet of Things*, IEEE Access, vol.4, May 2016, 22922 [ISSN: 21693536]
https://ieeexplore.ieee.org/document/7467408

Leslie Lamport, Robert Shostak, Marshall Pease 1982, *The Byzantine Generals Problem*, ACM Transactions on Programming Languages and Systems, July 1982, pp. 382-401
https://www.microsoft.com/en-us/research/uploads/prod/2016/12/The-Byzantine-Gene rals-Problem.pdf

Supplementary / Recommended Article/Paper Resources

Deloitte 2018, *Breaking blockchain open: Deloitte's 2018 global blockchain survey*
https://www2.deloitte.com/content/dam/Deloitte/cz/Documents/financial-services/c z-2018-deloitte-global-blockchain-survey.pdf

KPMG *Consensus – Immutable agreement for the internet of value*
https://assets.kpmg.com/content/dam/kpmg/pdf/2016/06/kpmg-blockchain-consensus-m echanism.pdf

This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Martin Collier	75008157
Semester 2	Martin Collier	75008157
Autumn	Martin Collier	75008157

Module Teachers	
Staff Member	*Staff Email*
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Martin Collier	Martin.Collier@dcu.ie

EE517: Network Analysis and Dimensioning (Semester:1 Core)

Title:	Network Analysis and Dimensioning APPROVED
Long Title:	Network Analysis & Dimensioning
Language of Instruction:	English

Module Code:	EE517

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Conor McArdle

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The aim of this module is to introduce the theory and practice of mathematical network analysis and optimisation methods as they apply to the problems of performance analysis of communications protocols, network dimensioning and capacity planning, network architecture design and traffic analysis in modern large-scale data networks, such as optically switched metro and access networks, datacenter and high performance computing interconnects, and femto-macro cell wireless network architectures. Network analysis is essential to understanding and evaluating the fundamental performance properties (e.g. latency, jitter, throughput, packet-drop rate) of complex network architectures and communications protocols. Network dimensioning methods are essential to planning and deploying large-scale networks under given capacity and cost constraints. This module will cover fundamental theory in probability, stochastic processes, queuing theory, graph theory and optimisation methods and apply them to solving various data network design and performance management problems.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Derive key results in queuing and teletraffic theory, as apply to the study of communication network performance analysis.
LO2	Apply methods from probability and queuing theory to modelling of performance-related behaviour of a range of packet-switched and circuit-switched systems and networks.
LO3	Apply queuing theory equations to calculate system performance measures (e.g. latency, throughput, packet loss) and to perform basic dimensioning of network resources to meet required performance targets.
LO4	Develop a number of different probabilistic traffic models and determine their applicability to representing different network traffic types.
LO5	Formulate a range of different network flow and resource dimensioning problems as mathematical optimisation problems.
LO6	Apply optimisation theory to solving network flow, routing and resource allocation problems.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
Knowledge of basic probability and queuing theory. Basic knowledge of data networks and protocols.

EE517: Network Analysis and Dimensioning
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Course Introduction The what and why of network analysis and dimensioning. Typical questions answered by network analysis methods. Typical network design problems solved using dimensioning methods. Overview of the methods and the required mathematical background and tools.
Review of Probability, Stochastic Processes and Markovian Queuing Systems Probability spaces, random variables, distribution functions, moment generation functions and transform methods, renewal processes, the Poisson process, continuous-time Markov Chains and Markovian queuing systems.
Loss Systems and Applications to Blocking Network Analysis and Design The Erlang-B and Engset systems. Blocking in non-Markovian queues, Equivalent Random Theory (ERT), networks with blocking and the reduced load approximation. Applications to performance analysis of wavelength division multiplexed (WDM) optically-switched networks and hierarchical cellular networks.
Quasi-Markovian/Non-Markovian Queuing Models Semi-Markov processes, mean delay and the delay distribution in the M/G/1 queue. Mean delay in G/M/1 and GI/GI/1 queues. Application to analysis of polling networks and Passive Optical Network (PON) performance.
Network Traffic Modelling Interrupted Poisson Process (IPP), Markov Modulated Poisson Process (MMPP). Traffic autocorrelation, self-similar traffic, heavy tails and the Pareto distribution. Application to modelling of Internet, circuit-switched and transport traffic.
Network Optimisation Theory Linear Programming (LP), Integer Linear Programming (ILP). LP and ILP solution methods and software tools. Problems on graphs, network flow problems, link-path and node-link formulations.
Network Design and Dimensioning Problems Network dimensioning metrics, constraints and objectives. Uncapacitated and capacitated flow problems, optical network routing and wavelength assignment problem (RWA), network fairness problems, network topology design.

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Network performance analysis assignment	2,3	12.50	Week 6
Assignment	Network dimensioning/optimisation assignment	5,6	12.50	Week 10

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	n/a	1,2,3,4,5,6	75.00	End-of-Semester

Reassessment Pre-Requisite
Repeat examination *Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.*
Reassessment Description A continuous assessment resit is provided for this module.

DCU reserves the right to alter the nature and timings of assessment

EE517: Network Analysis and Dimensioning
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Theory and worked application examples.	36
Assignment Completion	Assignment 1 : Application of queueing network modelling methods to performance analysis of a communication system.	24
Assignment Completion	Assignment 2 : Application of optimisation solution methods to a network design/dimensioning problem.	24
Independent Study	Revision of lecture materials and prescribed reading.	104
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources

Donald Gross, John F. Shortle, James M. Thompson, Carl M. Harris 2008, *Fundamentals of Queueing Theory*, 4 Ed., Wiley [ISBN: 9780471791270]

Michał Pióro and Deepankar Medhi 2004, *Routing, Flow, and Capacity Design in Communication and Computer Networks*, 1 Ed., Elsevier [ISBN: 9780125571890]

Supplementary / Recommended Book Resources

Fayez Gebali 2008, *Analysis of Computer and Communication Networks*, 1 Ed., Springer [ISBN: 978038774437]

Biswanath Mukherjee 2006, *Optical WDM Networks*, 1 Ed., Springer [ISBN: 9780387291888]

Maciej Stasiak, Mariusz Głabowski, Arkadiusz Wiśniewski, Piotr Zwierzykowski 2010, *Modeling and Dimensioning of Mobile Networks: From GSM to LTE, From GSM to LTE*, 1 Ed., Wiley [ISBN: 9780470976036]

This module does not have any article/paper resources

This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Conor McArdle	80016642
Semester 2	Conor McArdle	80016642
Autumn	Conor McArdle	80016642

Module Teachers	
Staff Member	*Staff Email*
Conor McArdle	Conor.McArdle@dcu.ie

EE518: Photonic Applications and Technologies (Semester:1 Core)

Title:	Photonic Applications and Technologies APPROVED
Long Title:	Photonics applications and technologies
Language of Instruction:	English

Module Code:	EE518

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

moduleLearningOutcomeTaxonomy:	Blooms

Module Delivered In	no programmes

Administrator:	Jennifer McManis

Module Coordinator:	Prince Anandarajah

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	This module will provide the students with knowledge, skills, competencies, and understanding of the telecommunications landscape and the role, photonic technologies play in the operation of the heterogenous broadband networks. Building on the fundamental knowledge on optical communications, a deep insight into the requirements, both from a technology and business/cost point of view, of different network segments and how these are met will be introduced. A series of case scenarios will be presented, providing the students with a practical knowledge of network design, operation and performance metrics.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Demonstrate mastery and detailed appreciation of the theoretical founding principles and current implementation of optical communications.
LO2	Identify and categorise the constraints set by various optical network segments
LO3	Analyse the role of photonic technologies in each of the network segments.
LO4	Calculate the performance metrics and analyse reasons for system performance degradation in different sectors.
LO5	Evaluate potential optical network evolution paths/technology roadmaps
LO6	Specify mechanisms to deal with the trade-off between the spectral efficiency and transmission distance as applied to various sectors of the network.
LO7	Conduct literature searches, abstract and summarize relevant techniques in photonic applications, and demonstrate scientific report writing at a master's level.

moduleLearningOutcomeTaxonomy: Blooms							
#	**LO1**	**LO2**	**LO3**	**LO4**	**LO5**	**LO6**	**LO7**
C1	Y	Y	Y	Y	Y	Y	Y
C2	Y	Y	Y	Y	Y	Y	Y
C3		Y	Y	Y			
C4		Y		Y	Y		
C5		Y	Y				
C6	Y		Y	Y	Y	Y	Y
P1							
P2							
P3							
P4							
P5							
P6							
P7							
A1							
A2							
A3							
A4							
A5							

moduleLearningOutcomeTaxonomy Reference: Blooms		
#	**Taxonomy Description**	**Taxonomy Group**
C1	Knowledge	Cognitive
C2	Comprehension	Cognitive
C3	Application	Cognitive
C4	Analysis	Cognitive
C5	Synthesis	Cognitive
C6	Evaluation	Cognitive
P1	Perception	Psychomotor (Technical Skills)
P2	Set	Psychomotor (Technical Skills)
P3	Guided Response	Psychomotor (Technical Skills)
P4	Mechanism	Psychomotor (Technical Skills)
P5	Complex Overt Response	Psychomotor (Technical Skills)
P6	Adaptation	Psychomotor (Technical Skills)
P7	Origination	Psychomotor (Technical Skills)
A1	Receiving to Phenomena	Affective (Humanities)
A2	Responding to Phenomena	Affective (Humanities)
A3	Valuing	Affective (Humanities)
A4	Organizing Values	Affective (Humanities)
A5	Internalizing Values	Affective (Humanities)

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE518: Photonic Applications and Technologies (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Review of fundamentals of optical communications Fibre transmission; photonic components: lasers, photoreceivers, amplifiers; modulation methods and formats; detection methods
Core and metro networks Spectral efficiency and transmission distance limitations, WDM, UWDM and elastic optical networks, interface with higher network layers
Access networks Fixed and wireless networks requirements and architectures, coexistence of different access methods on the same infrastructure, data centre interconnects
Advanced and emerging photonic technologies Photonic integrated circuits (PICs), Silicon photonics, hybrid integration, novel optical amplifiers and transmission windows, spatial division multiplexing
Photonics sensing and imaging Fibre sensing: Stress, strain, temperature, pressure, distance measurements, LiDAR, gas sensing

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Performance evaluation and network design principles	1,2,3,4,5,6	10.00	n/a
Report(s)	Detailed report writing on the applications of photonics in selected industry fields.	1,5,7	15.00	Once per semester

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End of semester exam	1,2,3,4,5,6	75.00	End-of-Semester

Reassessment Pre-Requisite

Repeat examination
Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.

DCU reserves the right to alter the nature and timings of assessment

EE518: Photonic Applications and Technologies (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Classroom lectures (Online Synchronous and Asynchronous sessions)	36
Assignment Completion	Assignments and homeworks	30
Independent Study	Independent study and exam preparation	122
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Ivan Kaminow, Tingye Li and Alan Willner, *Optical Fiber Telecommunications VB, Systems and Networks*, 5th Ed. [ISBN: ISBN: 9780123] **Ivan Kaminow, Tingye Li and Alan Willner, *Optical Fiber Telecommunications VA, Components and Subsystems*, 5 Ed. [ISBN: ISBN: 9780123]** **John Senior, *Optical Fiber Communications: Principles and Practice*, 3 Ed. [ISBN: 13: 978-01303]**
Supplementary / Recommended Book Resources
Tarun Kumar Gangopadhyay,Pathik Kumbhakar,Mrinal Kanti Mandal 2019, *Photonics and Fiber Optics*, CRC Press [ISBN: 9780367134570]
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Prince Anandarajah	80014151
Semester 2	Prince Anandarajah	80014151
Autumn	Prince Anandarajah	80014151

Module Teachers	
Staff Member	*Staff Email*
No Teacher Staff Assigned	

EE519: Wireless Communications in Fading Channels (Semester:1 Core)

Title:	Wireless Communications in Fading Channels APPROVED
Long Title:	Wireless Communications in Fading Channels
Language of Instruction:	English

Module Code:	EE519

Credits:	7.5

NFQ Level:	9

Field of Study:	Communication Technologies

moduleLearningOutcomeTaxonomy:	Blooms

Module Delivered In	no programmes

Administrator:	Jennifer Bruton

Module Coordinator:	Conor Brennan

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	This module aims to develop a fundamental understanding of techniques which make possible reliable digital communications over wireless fading channels. Building on the analysis of simple digital modulation schemes over noisy non-fading channels it then introduces the concept of fading, along with its key physical characterisations (fast, slow, flat and frequency selective). These are derived in terms of the underpinning propagation phenomena and quantified in terms of key channel statistical metrics such as coherence bandwidth and coherence time. The module then examines the use of diversity techniques to improve the performance of digital modulation in fading channels. These include time, frequency and space diversity. In particular we shall examine the use of multiple antenna (MIMO) technology and space time coding. Emerging channel modelling techniques such as ray tracing will be introduced.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Evaluate the performance of digital modulation schemes for noisy AWGN channels and band-limited channels.
LO2	Describe the physical processes that generate fading as well as the simple metrics used to characterize channels such as coherence bandwith and coherence time.
LO3	Describe the wireless channel as a linear time varying system and derive a discrete-time baseband model
LO4	Analyse the performance of signalling techniques in a variety of fading channels.
LO5	Describe and analyse the effectiveness of time, frequency and space diversity techniques
LO6	Analyse the use of CDMA and OFDM to allow multiple access and manage interference.
LO7	Extend statistical channel models to the MIMO case and derive simple beamforming and spatial multiplexing techniques.
LO8	Numerically model selected topics in digital wireless communications using Matlab.

moduleLearningOutcomeTaxonomy: Blooms								
#	LO1	LO2	LO3	LO4	LO5	LO6	LO7	LO8
C1	Y	Y	Y	Y	Y	Y	Y	
C2		Y	Y	Y	Y	Y	Y	
C3			Y				Y	Y
C4	Y			Y	Y	Y		Y
C5								Y
C6	Y							Y
P1								
P2								
P3								
P4								
P5								
P6								
P7								
A1								
A2								
A3								
A4								
A5								

moduleLearningOutcomeTaxonomy Reference: Blooms		
#	Taxonomy Description	Taxonomy Group
C1	Knowledge	Cognitive
C2	Comprehension	Cognitive
C3	Application	Cognitive
C4	Analysis	Cognitive
C5	Synthesis	Cognitive
C6	Evaluation	Cognitive
P1	Perception	Psychomotor (Technical Skills)
P2	Set	Psychomotor (Technical Skills)
P3	Guided Response	Psychomotor (Technical Skills)
P4	Mechanism	Psychomotor (Technical Skills)
P5	Complex Overt Response	Psychomotor (Technical Skills)
P6	Adaptation	Psychomotor (Technical Skills)
P7	Origination	Psychomotor (Technical Skills)
A1	Receiving to Phenomena	Affective (Humanities)
A2	Responding to Phenomena	Affective (Humanities)
A3	Valuing	Affective (Humanities)
A4	Organizing Values	Affective (Humanities)
A5	Internalizing Values	Affective (Humanities)

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE519: Wireless Communications in Fading Channels (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Review of required mathematics: Fourier analysis, probability and random processes, systems.
Introduction to digital communications and wireless communications source coding, digital modulation, propagation, channel coding, fundamental constraints, capacity, radiowave propagation, cellular systems and networks,
Baseband digital communications: binary bandwidth limited signals and inter-symbol interference, noise and bit errors, adaptive equalization. Band pass digital systems: Binary PSK and QPSK.
The wireless channel: physical modelling for wireless channels, reflections, the effect of mobility, the channel as a linear time varying system, Doppler spread and coherence time, delay spread and coherence bandwidth, statistical channel models, Rayleigh and Ricean fading,
Coherent detection in Rayleigh fading channels. Time diversity – repetition coding, frequency diversity: ISI equalization, direct sequence spread spectrum, orthogonal frequency division multiplexing. Channel estimation and non coherent detection.
Modelling of MIMO fading channels: channel matrix, statistical modelling in angular domain, degrees of freedom and diversity. Deterministic channel modelling and ray tracing.

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Completion of online activity	Webwork-based homeworks	1,2,3,4,5,6,7	10.00	n/a
Assignment	Matlab assignments	8	15.00	n/a

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End of semester exam	1,2,3,4,5,6,7	75.00	End-of-Semester

Reassessment Pre-Requisite
Repeat examination *Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.*
Reassessment Description Repeat Examination: Reassessment of this module will consist of a repeat examination.

DCU reserves the right to alter the nature and timings of assessment

EE519: Wireless Communications in Fading Channels (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Classroom lectures	36
Assignment Completion	Assignments and homeworks	36
Independent Study	Independent study and exam preparation	116
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
David Tse and Pramod Viswanath, *Fundamentals of Wireless Communication*, Cambridge University Press [ISBN: 978-052184527] **Andrea Goldsmith, *Wireless Communications*, Cambridge University Press [ISBN: 978-052183716]** **Andreas F Molisch, *Wireless Communications*, Wiley-IEEE [ISBN: 978-047074186]** **Simon Haykin 2013, *Digital Communication Systems*, Wiley [ISBN: 9780471647355]** **John Proakis, *Digital Communications*, McGraw Hill [ISBN: 978007295716]**
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Conor Brennan	80007139
Semester 2	Conor Brennan	80007139
Autumn	Conor Brennan	80007139

Module Teachers	
Staff Member	*Staff Email*
Conor Brennan	Conor.Brennan@dcu.ie

EE521: Future Network Architectures (Semester:1 Core)

Title:	Future Network Architectures APPROVED
Long Title:	Future Network Architectures
Language of Instruction:	English

Module Code:	EE521

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

moduleLearningOutcomeTaxonomy:	Blooms

Module Delivered In	no programmes

Administrator:	Jennifer McManis

Module Coordinator:	Martin Collier

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	This module will equip students to operate and design future data networks with aggregate capacities in the petabit/s region. The principles of network architecture design to achieve the necessary scale and efficiency of operation will be developed, as will the range of acceleration techniques required to inject data into and extract it from the network at tomorrow's wire speeds. Techniques for the orchestration of resources and network reconfiguration in data centre networks and at the network edge will be explored, and their use in deploying virtual networks and network slices will be evaluated.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	understand the principles of data centre network design
LO2	select an appropriate network topology for a data centre network, given its predicted load
LO3	apply methods of packet acceleration to achieve wire speed on the fastest network interfaces
LO4	partition networks in the control plane using layer 2 and layer 3 approaches
LO5	select appropriate packet scheduling algorithms to support network slicing and traffic engineering
LO6	specify techniques for intrusion detection and firewalling appropriate to future network architectures
LO7	evaluate a range of new approaches to content delivery in future networks

moduleLearningOutcomeTaxonomy: Blooms							
#	**LO1**	**LO2**	**LO3**	**LO4**	**LO5**	**LO6**	**LO7**
C1		Y	Y	Y	Y	Y	Y
C2		Y	Y	Y	Y	Y	Y
C3	Y	Y	Y	Y	Y	Y	
C4		Y			Y	Y	
C5		Y	Y	Y			
C6	Y		Y	Y		Y	Y
P1							
P2							
P3							
P4							
P5							
P6							
P7							
A1							
A2							
A3							
A4							
A5							

moduleLearningOutcomeTaxonomy Reference: Blooms		
#	**Taxonomy Description**	**Taxonomy Group**
C1	Knowledge	Cognitive
C2	Comprehension	Cognitive
C3	Application	Cognitive
C4	Analysis	Cognitive
C5	Synthesis	Cognitive
C6	Evaluation	Cognitive
P1	Perception	Psychomotor (Technical Skills)
P2	Set	Psychomotor (Technical Skills)
P3	Guided Response	Psychomotor (Technical Skills)
P4	Mechanism	Psychomotor (Technical Skills)
P5	Complex Overt Response	Psychomotor (Technical Skills)
P6	Adaptation	Psychomotor (Technical Skills)
P7	Origination	Psychomotor (Technical Skills)
A1	Receiving to Phenomena	Affective (Humanities)
A2	Responding to Phenomena	Affective (Humanities)
A3	Valuing	Affective (Humanities)
A4	Organizing Values	Affective (Humanities)
A5	Internalizing Values	Affective (Humanities)

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE521: Future Network Architectures (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Data centre network design switch architectures, Clos networks, fat trees, VLANs and VXLAN, open vSwitch, InfiniBand, RDMA, data centre bridging, P4, content delivery networks
Control Plane processes signalling protocols, OpenFlow, SDN, SDN controllers, network slicing, BGP
Data Plane and packet acceleration packet aggregation, bypass, eXpress Data Path, DPDK, vector packet processing, hardware accelerators, longest prefix match, NFV, NFV MANO, queueing disciplines
Firewalls and security intrusion detection, eBPF, firewall appliances, BGP security, deep packet inspection
Emerging network protocols IPv6, IoT protocols, 5G, multihoming and multipath networking, information-centric networking, time-sensitive networking,

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	A written report addressing a problem in the design of future network architectures. Students must demonstrate that their solution meets the security, reliability and performance requirements posed in the problem, and must compare technical approaches in arriving at their solution.	1,2,3,4,5	25.00	Week 10

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	n/a	2,3,4,5,6,7	75.00	End-of-Semester

Reassessment Pre-Requisite
Repeat examination *Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.*
Reassessment Description Resit terminal examination and resubmit CA

DCU reserves the right to alter the nature and timings of assessment

EE521: Future Network Architectures (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Assignment Completion	No Description	30
Independent Study	No Description	122
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources

Steven Noble 2017, *Building Modern Networks*, Packt Publishing [ISBN: 9781786466976]

Deep Medhi, Karthik Ramasamy 2018, *Network Routing: Algorithms, Protocols, and Architectures*, 2nd Ed., Morgan Kaufmann [ISBN: 978012800737]

Rajendra Chayapathi, Syed F. Hassan, Paresh Shah 2017, *Network Functions Virtualization (NFV) with a Touch of SDN*, Addison-Wesley Professional [ISBN-13: 9780134464336]

Supplementary / Recommended Book Resources

Gary Lee 2014, *, Cloud Networking: Developing Cloud-Based Data Center Networks*, Morgan Kaufmann, [ISBN 978-0-12-800728-0]

Paul Göransson, Chuck Black and Timothy Culver 2017, *Software Defined Networks: A Comprehensive Approach*, 2nd Ed., Morgan Kaufmann, [ISBN: 978-0-12-804555-8]

Ken Gray, Thomas Nadeau 2016, *Network Function Virtualization*, Morgan Kaufmann, [ISBN: 9780128021194]

This module does not have any article/paper resources

Other Resources

ebook: William James Dally, Brian Towles 2004, *Principles and Practices of Interconnection Networks*, Morgan Kaufman
https://dl.acm.org/doi/pdf/10.5555/28215 89

vendor whitepaper: Ericsson*Future network architecture*
https://www.ericsson.com/en/future-techn ologies/architecture

vendor whitepaper: Huawei*5G Network Architecture*
https://carrier.huawei.com/~/media/CNBG/ Downloads/Program/5g_nework_architecture _whitepaper_en.pdf

vendor whitepaper: Nokia*IP/optical interworking for 5G*
https://pf.content.nokia.com/t004ok-webs cale-ip-optical-integration/ip-optical-i nterworking-white-paper

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Martin Collier	75008157
Semester 2	Martin Collier	75008157
Autumn	Martin Collier	75008157

Module Teachers	
Staff Member	*Staff Email*
Martin Collier	Martin.Collier@dcu.ie

EE535: Energy System Decarbonisation (Semester:1 Core)

Title:	Energy System Decarbonisation APPROVED
Long Title:	Energy System Decarbonisation: Technology and Policy
Language of Instruction:	English

Module Code:	EE535

Credits:	7.5

NFQ Level:	9

Field of Study:	Electricity and energy

Module Delivered In	19 programme(s)

Administrator:	Conor McArdle

Module Coordinator:	Barry McMullin

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Presents core concepts in the technology and policy challenges of energy system decarbonisation, including key drivers and constraints, nationally and internationally (climate change, resource depletion, sustainable development). Enables students to engage in critical analysis of consequent technical, social, political and business policy issues.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Explain the challenges of climate change and fossil fuel resource depletion at global and national levels.
LO2	Explain the system characteristics of key energy supply technologies (FF, VRE, BE, CCS, Nuclear fission).
LO3	Explain the system characteristics of energy consumption (sectors: heat, transport, electricity; demand reduction, efficiency, rebound).
LO4	Explain the potential decarbonisation roles of diverse energy conversion and storage technologies.
LO5	Critically assess alternative decarbonisation strategies and corresponding energy system configurations and evolution.
LO6	Critically discuss the interactions between climate, energy, development, ethics and justice (globally and nationally).
LO7	Formulate and critically assess policy proposals in relation to energy system decarbonisation.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE535: Energy System Decarbonisation (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Introduction to climate science and policy Planetary energy balance; role of greenhouse gases; CO2 as a cumulative (stock) pollutant; risks; mitigation and adaptation; UNFCCC, Paris Agreement; temperature goals; global carbon quota; common but differentiated responsibilities and capabilities, equity, justice. Scale and urgency of required mitigation.
Energy fundamentals Energy concept, conservation (1st Law of Thermodynamics), units, flows (power), usable energy/exergy, degradation (2nd Law of Thermodynamics), forms (mechanical, chemical, thermal etc.), conversion, efficiency, energy return on energy invested (EROEI), embodied energy, storage.
Energy supply Dominance of fossil fuels (FF); resource depletion; variable renewables (VRE: wind, solar); Bioenergy (BE); carbon capture and storage (CCS); nuclear fission; hydro; geothermal; wave and tidal.
Energy consumption Coupling with material needs, economic activity (GDP); efficiency, rebound; constraint, equity (national, global); sectors: heating, transport (including aviation and shipping), electricity.
Carbon Dioxide Removal (CDR) Forestry, soil carbon, bioenergy with carbon capture and storage (BECCS), direct air carbon capture and storage (DACCS), enhanced weathering; interactions with the energy system.
Energy system integration and decarbonisation Supply mix, balance, electrification of heat and transport, dealing with variability (VRE): over capacity, curtailment, storage; electricity transmission, distribution, smart grid, interconnection, demand management, demand constraint.
Policy and governance Energy system "trilemma" (security, "sustainability", cost); regulation, market based measures; EU instruments (Renewable Energy Directive, Emissions Trading System, Effort Sharing Decision/Regulation, Governance of the Energy Union); Tradable Energy Quotas (TEQs); carbon taxation; ethics, equity, just transition; roles of government, business, citizens; societal communication and engagement.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	Concise book review of one assigned course text.	1,2	20.00	Week 3
Assignment	Quantitative analysis of the "fair share" cumulative CO2 quota for a given target country, aligned with the Paris Agreement temperature goals.	1,6,7	30.00	Week 6
Assignment	Develop an energy system decarbonisation pathway for a given target country, aligned with the Paris Agreement temperature goals.	1,2,3,4,5,6,7	50.00	Week 9

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE535: Energy System Decarbonisation (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Course Material & Discussion	36
Independent Study	Study and Assignments	151
	Total Hours	187.00

This module has no Part Time workload.

Module Resources

Essential Book Resources

Richard Heinberg, David Fridley 2016, *Our Renewable Future: Laying the Path for One Hundred Percent Clean Energy*, Post-Carbon Institute [ISBN: 978-161091779]

David MacKay 2009, *Sustainable Energy - without the Hot Air*, UIT Cambridge [ISBN: 978-095445293]

Supplementary / Recommended Book Resources

Henrik Lund 2014, *Renewable energy systems: a smart energy systems approach to the choice and modeling of 100% renewable solutions*, 2 Ed., Academic Press [ISBN: 9780124104235]

Walt Patterson 2015, *Electricity Vs Fire: The Fight For Our Future* [ISBN: 978-099326120]

Supplementary / Recommended Article/Paper Resources

UNFCCC 2015, *The Paris Agreement*
http://unfccc.int/files/essential_background/convention/application/pdf/english_ paris_ agreement.pdf

Department of Communications, Energy and Natural Resources [Ireland] 2015, *[White paper] Ireland's Transition to a Low Carbon Energy Future 2015-2030*
http://tinyurl.com/yaq4uv99

David Roberts *A beginner's guide to the debate over 100% renewable energy*, vox.com, Updated Feb 6, 2018
https://www.vox.com/energy-and-environment/2017/4/4/14942764/100-renewable-energ y-debate

Other Resources

website: European Commission*[EU] 2030 climate & energy framework*
https://ec.europa.eu/clima/policies/stra tegies/2030_en

website: David Connolly 2014, *Green Plan Ireland*
http://dconnolly.net/greenplanireland/

film: Trócaire 2016, *The Burning Question [documentary]*
http://tinyurl.com/yckeqeyw

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
MEPM	MEng	1	Option
EEPM	MEng	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
CAPM	MSc	1	Option
EEPD	PhD	1	Option
MEPD	PhD	1	Option
CAPD	PhD	1	Option
EEPT	PhD-track	1	Option
MEPT	PhD-track	1	Option
CAPT	PhD-track	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Barry McMullin	75008378
Semester 2	Barry McMullin	75008378
Autumn	Barry McMullin	75008378

Module Teachers	
Staff Member	*Staff Email*
Barry McMullin	Barry.McMullin@dcu.ie

EE544: Computer Vision
(Semester:1 Core)

Title:	Computer Vision
Long Title:	Computer Vision (Incorporating Deep Learning)
Language of Instruction:	English

Module Code:	EE544

Credits:	7.5

NFQ Level:	9

Field of Study:	Artificial Intelligence & Signal & Image Processing

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Paul Whelan

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Computer vision applications have significantly expanded over the last decade and this core skill set is always in high demand by employers. This module will build on the basic concepts with a view to delving deeper into core computer vision, machine learning and deep learning topics. As well as examining traditional computer vision concepts (i.e. feature extraction and machine learning) a key focus of the module will be on deep learning as applied to computer vision. We will examine the core concepts behind deep learning for computer vision with a specific focus on Convolutional Neural Networks (CNN). Students will learn how to design and tune such networks in a range of practical applications and assignments. In addition we will examine a range of deep learning architectures ranging from AlexNet upto the current state of the art in this ever expanding field. Deep learning based computer vision forms the core of many of the recent developments in this field and has been widely adopted as a core AI tool by all the key industrial players such as Google, Facebook, IBM, Apple, Baidu ... as well as a wide range of highly innovative startups. All computer vision and deep learning concepts will be reinforced by guided practical work and case studies. This module is primarily aimed at those who aim to undertake research in computer vision or require a deeper understanding of the subject to address commercial computer vision development. Computer vision applications span a wide range of disciplines including industrial/machine vision, video data processing, biomedical engineering, healthcare, astronomy, imaging science, sensor technology, multimedia and enhanced reality systems. Please refer to the modules summary syllabus for a breakdown of the course content. This module will require basic programming skills. See the EE544 module website (http://www.eeng.dcu.ie/~whelanp/ee544/) for details on the computer vision & deep learning development environment.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Recall, review and analyse the advanced theories, algorithms, methodologies and techniques involved in traditional and deep learning based computer vision.
LO2	Illustrate their ability to comprehend and interpret issues relating to the design of advanced traditional and deep learning based computer vision.
LO3	Synthesize and evaluate the relevant merits of competing advanced computer vision techniques.
LO4	Apply computer vision techniques in a range of application scenarios.
LO5	Develop an deep understanding of the issues involved in the evaluating computer vision system implementation.
LO6	Demonstrate the ability to implement a computer vision pipeline.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
This module will require basic programming skills.

EE544: Computer Vision
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Introduction • Introduction to Python Computer Vision Development Environment • Computer vision Pipeline • Traditional vs deep learning approaches to computer vision • Learning Outcomes • Module Protocol • Assessment Requirement • Support Material & Website • Software Tools • Case Studies
Interest Point Detection & Feature Extraction • SIFT - Scale Invariant Feature Transform • Histogram of Oriented Gradients (HOG) • Deformable Part Models (DPM)
Machine Learning for Computer Vision • Classification • Feature Normalisation • Evaluation of Classifier Performance • Non-Parametric Classifiers / Decision Trees (DT) • Support Vector Machine (SVM) • SVM Multi-class Classification
Deep Learning for Computer Vision (ANN & CNN) • Artificial Neural Networks • Logistic (Linear) Classifier • Gradient Descent / Stochastic Gradient Descent (SGD) • Backward Propagation • Regularisation Methods • Supervised Deep Learning • Convolution Neural Networks • Transfer Learning • Architectures • Unsupervised Learning
Deep Learning for Computer Vision (Classification, Visualisation & Localisation) • CNN classification • Data Augmentation • Visualising CNN filters • Localise Objects with Regression • Object Detection as Classification • Region-Based CNN (R-CNN) • Single Shot Detectors (SSD)
Deep Learning for Computer Vision (Segmentation, Detection & Advanced) • Semantic Segmentation • Fully Convolutional Networks • Instance Segmentation • Style Transfer Network • Deep Dream • Generative Adversarial Networks
Motion • Optical Flow: 2D • Optical Flow Constraints • Local / Global Approaches • Feature Matching – Motion Correspondence • Kanade Lucas Tomasi (KLT) Tracking

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Practical/skills evaluation	Practical assignments consisting of a number of computer vision design workbooks.	1,2,3,4,5,6	25.00	n/a

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	1,2,3,4,5,6	75.00	End-of-Semester

DCU reserves the right to alter the nature and timings of assessment

EE544: Computer Vision
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	This module is presented in a traditional format (lecture and continuous assessment) with significant practical support: Including: pdf versions of the class slides, screencast videos, computer vision, ML, DL development environment (used for the assignments and to illustrate all module concepts) and selected examples and case studies.	36
Independent Study	General revision and practice, Coursework, Online activity with module material. Homeworks and tutorials.	151.5
	Total Hours	187.50

This module has no Part Time workload.

Module Resources

Essential Book Resources
Paul F Whelan, *Online course notes (slides)*
Richard Szeliski, *Computer Vision: Algorithms and Applications*, Springer
Christopher M. Bishop, *Pattern recognition and machine learning*, Springer
Ian Goodfellow and Yoshua Bengio and Aaron Courville, *Deep Learning*, MIT Press http://www.deeplearningbook.org
Supplementary / Recommended Book Resources
Richard O. Duda, Peter E. Hart, David G. Strok, *Pattern classification*, John Wiley & Sons
David A. Forsyth, Jean Ponce, *Computer vision*, Pearson Education
Richard Hartley, Andrew Zisserman, *Multiple view geometry in computer vision*, Cambridge University Press
Essential Article/Paper Resources
Research papers from leading computer vision journals
Other Resources
Module Website: *EE544* http://www.eeng.dcu.ie/~whelanp/ee544/ee 544_notes.html
Lecturer Website: *paulwhelan.eu* http://paulwhelan.eu/

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Paul Whelan	75015803
Semester 2	Paul Whelan	75015803
Autumn	Paul Whelan	75015803

Module Teachers	
Staff Member	*Staff Email*
Paul Whelan	Paul.Whelan@dcu.ie

EE559: Nanoelectronics Technology (Semester:1 Core)

Title:	Nanoelectronics Technology APPROVED
Long Title:	Nanoelectronics Technology
Language of Instruction:	English

Module Code:	EE559

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	10 programme(s)

Administrator:	Patrick McNally

Module Coordinator:	Patrick McNally

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	Nanoelectronics has become one of the most important and exciting fields in the forefront of engineering, physics, chemistry and biology. The technology and the possibilities of engineering at the nanoscale shows great promise for delivering many breakthroughs that will impact on technological advances in a wide range of applications from chemical to electronic to optronic to medical.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Demonstrate a graduate level of knowledge of the applications of Nanotechnology and Nanoelectronics.
LO2	Possess the technical capability to appreciate and contribute to the technical development in the field.
LO3	Show a skill set that captures the interdisciplinarity of nanoscale engineering and science.
LO4	Solve scientific and engineering related problems based on a major homework problem set related to course material.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE559: Nanoelectronics Technology
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Indicative Syllabus Introduction to Quantum Mechanics: Classical particles and phenomena, wave packets, why quantum mechanics?; the Bohr atomic model; matter waves, the quantum wavefunction, the Schrödinger equation, Heisenberg uncertainty principle, quantum wells. Introduction to Physics of the Solid State: Crystal structure and lattice vibrations; energy bands, reciprocal space, effective masses, Fermi surfaces, localised particles e.g. donors, traps, excitons. Methods of Measuring Properties: Crystallography – X-Ray Diffraction. Carbon Nanostructures: Carbon molecules, carbon clusters – C60 and fullerenes; carbon nanotubes; applications of carbon nanotubes. Graphene. Bulk Nanostructured Materials: Photonic crystals. Nanostructured Ferromagnetism: Theory of Ferromagnetism and applications to storage and spintronic systems: dynamics of nanomagnets, giant and colossal magnetoresistance; spintronics and memory applications incl. magnetic tunnel junctions (MTJs), spin torque transfer systems for magnetoresistive random access memory (MRAM). Quantum Wells, Wires and Dots: Preparation; size and dimensionality effects; excitons; single-electron tunnelling; applications – IR detectors, quantum dot lasers. Nano Machines and Devices: Microelectromechanical systems (MEMS); nanoelectromechanical systems (NEMS). Optical and Vibrational Spectroscopy: Excitons; infrared surface spectroscopy; Raman spectroscopy; Luminescence – photoluminescence and thermal wave techniques. Nanoelectronics & Quantum Computation: Wavefunction and operator approaches to quantum mechanics; Dirac's Braket notation; qubits; registers of qubits; single and multi-dimensional quantum gates; simple quantum computation algorithms; physical realisation of qubits – quantum dot computation system(s).

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Assignment	A time-limited Take-Home Examination comprising of circa 10 high level of difficulty problems Which will interrogate all aspects of the taught materials in the module. The questions are synchronised to the different classes and the students will be able to progress serially through the Take-home Examination only after they have read and understood the Lectures and Lecture Notes.	1,2,3,4	70.00	Sem 1 End
Assignment	The students will be given copies of seminal Research Paper published in recent years. This Research Paper will have had a major impact on Nanoelectronics Technology, and a selection of these will be distributed to the individual students in order to ensure that they are not all addressing the same seminal Research Paper. Certain sections of the paper will be slightly above the level of difficulty the students will have encountered during their Lectures, and they will be expected to use that knowledge to develop a critical understanding of this paper.	1,2,3	30.00	n/a

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE559: Nanoelectronics Technology (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	Lectures: synchronous and asynchronous.	36
Assignment Completion	Take-home examination and research paper critique	80
Independent Study	Independent study	72
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Module Web Notes and Lecture Videos on LOOP **Vladimir Mitin, Viatcheslav Kochelap, Michael A. Stroscio 2008, *Introduction to nanoelectronics*, Cambridge University Press Cambridge [ISBN: 978-0-521-88172-2]**
Supplementary / Recommended Book Resources
Marc Baldo 2011, *Introduction to Nanoelectronics*, FREE eBOOK Ed., MIT OpenCourseWare Publication http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-701-introduction-to-nanoelectronics-spring-2010/readings/MIT6_701S10_notes.pdf **Douglas Natelson 2015, *Nanostructures and Nanotechnology*, Cambridge University Press [ISBN: 9780521877008]**
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Patrick McNally	75018535
Semester 2	Patrick McNally	75018535
Autumn	Patrick McNally	75018535

Module Teachers	
Staff Member	*Staff Email*
Patrick McNally	Patrick.McNally@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Deiric O'Broin	deiric.obroin@dcu.ie

EE562: Network Stack Implementation (Semester:1 Core)

Title:	Network Stack Implementation APPROVED
Long Title:	Network Stack Implementation
Language of Instruction:	English

Module Code:	EE562

Credits:	7.5

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	10 programme(s)

Administrator:	Noel Murphy

Module Coordinator:	Martin Collier

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	The aim of the module is to introduce students to the software embedded in network devices such as routers to implement network protocols. Where possible, open source implementations of protocols used in live networks will be studied. Both the data plane and the control plane will be studied, including data-link layer protocols, network layer protocols and transport layer protocols. Optimisation techniques, hardware acceleration and other approaches to achieving “wire speed” operation will be investigated. Protocols appropriate to the Internet of Things, to data centres, and to the future Internet will be considered.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	to classify network functionality as belonging to the control plane and the data plane respectively
LO2	explain how a typical operating system processes packets from arrival from an interface card to forwarding to user space
LO3	describe the principles involved in implementing a network stack in software
LO4	decompose the software of “middleboxes” such as network routers into a software architecture
LO5	evaluate the trade-offs involved in hardware versus software implementation of packet processing functions
LO6	demonstrate advanced theoretical knowledge of networking
LO7	add functionality to an open-source network stack
LO8	adapt existing software to meet new networking requirements

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
Knowledge of a procedural or object-oriented programming language. Knowledge of the basic principles of packet switching.

EE562: Network Stack Implementation (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Low Level Issues Bridging overview, Ethernet, 6LoWPAN, Wi-fi, Data rates, hardware vs. software Router architecture, network device drivers, buffer management.
Network Layer route pinning and datagram routing IPv4, IPv6, firewalling and NAT.
Transport Layer Review of sockets, TCP protocol description Implementation of TCP Multi-homing, multi-path, congestion
Control Plane Control Plane vs. Data Plane Internet routing protocols (RIP, OSPF, BGP). Router configuration and network administration. Why is signalling needed? End-to-end signalling SDN and OpenFlow QoS and resource reservation
Advanced Packet Forwarding Deep packet probes, policy-based routing, Hardware acceleration, network processors

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Research Paper	An evaluation of one or more aspects of network stack implementation in the format of a research paper.	3,4,5,6,7,8	25.00	Once per semester

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	End-of-Semester Final Examination	1,2,3,4,5,6,7,8	75.00	End-of-Semester

Reassessment Pre-Requisite

Repeat examination
Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.

DCU reserves the right to alter the nature and timings of assessment

EE562: Network Stack Implementation (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Lecture	No Description	36
Assignment Completion	No Description	44
Independent Study	No Description	108
	Total Hours	188.00

This module has no Part Time workload.

Module Resources

Essential Book Resources

Christian Benvenuti 2006, *Understanding Linux Network Internals*, 1st ed. Ed., O'Reilly Media, Inc. [ISBN: 0596002556]

Rami Rosen 2014, *Linux Kernel Networking: Implementation and Theory*, 1st ed. Ed. [ISBN: 9781430261964]

This module does not have any article/paper resources

Other Resources

Blog entry: *No Title*
http://www.tune2wizard.com/kernel-progra mming-network-programming/

Blog entry: *No Title*
https://www.privateinternetaccess.com/bl og/2016/01/linux-networking-stack-from-t he-ground-up-part-1/

Blog entry: *No Title*
https://blog.packagecloud.io/eng/2016/06 /22/monitoring-tuning-linux-networking-s tack-receiving-data/

Blog entry: *No Title*
http://www.cubrid.org/blog/dev-platform/ understanding-tcp-ip-network-stack/

Article: Dan Siemon 2013, *Queueing in the Linux Network Stack*
https://www.coverfire.com/articles/queue ing-in-the-linux-network-stack/

Article: Arnout Vandecappelle*Kernel Flow*, The Linux Foundation
https://wiki.linuxfoundation.org/network ing/kernel_flow

Slide Show: Thomas Graf*Kernel Networking Walkthrough*, Red Hat
http://www.slideshare.net/ThomasGraf5/de vconf-2014-kernel-networking-walkthrough

Blog Entry: 2011*How to Write a Linux Firewall in Less than 1000 Lines of Code*
http://www.roman10.net/2011/07/23/a-linu x-firewall-using-netfilter-part-1overvie w/

Module Delivered In

Programme Code	Programme	Semester	Delivery
BNS	Bachelor of Nursing Studies (Hons)	1	Option
BNS	Bachelor of Nursing Studies (Hons)	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Martin Collier	75008157
Semester 2	Martin Collier	75008157
Autumn	Martin Collier	75008157

Module Teachers	
Staff Member	*Staff Email*
Gabriel-Miro Muntean	gabriel.muntean@dcu.ie
Martin Collier	Martin.Collier@dcu.ie

EE580: Masters Project-IoT Major
(Semester:1 Core)

Title:	Masters Project-IoT Major APPROVED
Long Title:	Masters Project - IoT Major
Language of Instruction:	English

Module Code:	EE580

Credits:	30

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Jennifer McManis

Module Coordinator:	Marissa Condon

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To allow the student to put theoretical knowledge of engineering to use in a practical project related to the Internet of Things (IoT) and to document the project outputs to research publication standard. In this module students will use and develop knowledge and skills in planning and managing projects, risk and health & safety assessments, reviewing literature, analysing, defining and implementing an engineering solution, documenting and presenting outcomes and key findings.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe and explain the scientific principles and engineering technologies and design processes associated with their project area
LO2	Identify engineering problems and to formulate problems in a manner which allows solution
LO3	Display a level of ingenuity in applying appropriate existing solutions or devising novel solutions to engineering design problems
LO4	Devise appropriate tests or experiments in order to allow exploration, analysis and evaluation of a proposed system design
LO5	Apply critical analysis to the results of tests or experiments and to draw concrete conclusions as to the effectiveness of an engineering design
LO6	Identify technical requirements for a design and to assess the practicality of possible solutions to problems arising in the project
LO7	Write well structured engineering reports which are written to the correct level of technical detail to suit the intended reader
LO8	Apply project management techniques in the execution of the project in order to undertake all project implementation and development work and to produce a complete project report to deadline
LO9	Take responsibility for progression of their own work under guidance of a supervisor and to identify and report problems and issues as they arise which might impede progress of a project
LO10	Conduct the required background research related to the project topic and be able to search for, access, review and evaluate publications on given topics
LO11	Distinguish between their own work and that of others and to credit others' in a proper manner
LO12	Resolve differences of opinion on technical matters between themselves and their supervisor
LO13	Effectively communicate technical concepts and ideas orally, in writing and graphically
LO14	Search research journals, the Internet, and other resources for relevant research approaches and to evaluate and compare these
LO15	Use statistical approaches, critical analysis, quantitative and qualitative comparisons to evaluate the quality of their own work and that of others
LO16	Communicate complex technical ideas to a lay audience
LO17	Report their research results to publication standard in the format of an academic paper
LO18	Document their results in a hierarchical manner, with fine detail delegated to appendices and key points in the main report

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE580: Masters Project-IoT Major
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Research Training Participation in research training activities in support of the literature review task.
Literature Review & Analysis of the Problem Conduct a critical analysis of the state-of-the-art research and engineering technologies relevant to the project problem to identify suitable, well-founded solution approaches. Maintenance of a student Research Log on an ongoing basis, capturing key findings and conclusions from reading of literature.
Presentation Preparation & Delivery Presentation of key information, ideas and conclusions from the literature review and problem analysis, reporting progress on preliminary project design, evaluation of suitable methods, tools and technologies for implementation, experimentation, testing.
Project Plan Development of an approved solution method and detailed project plan for completing a well-grounded engineering implementation that will fulfill the project objectives.
Implementation of Solution Activities carried out to implement the project plan. May take many forms – system implementation and testing, experimental laboratory work, computer based modelling and analysis, etc.
Testing & Analysis of Results Designing appropriate tests and evaluating the outcome from these. Identifying and assessing new knowledge developed during the project in a critical and insightful manner.
Documentation of Outcomes Production of a conference paper documenting the solution approach, its relation to the state-of-the-art, results obtained and key findings and conclusions from the project outputs. Compiling a portfolio of supporting appendix materials. Attendance at final project interview with project assessors.
Communications with supervisor, technical support & others Arranged communications to discuss the advancement of the project and the technical resources required.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	Research Methodologies MCQ	10,11,14	1.00	Other
Research Paper	Literature Review	1,2,6,7,9,10,11,13,14	9.00	Other
Presentation	Oral Presentation	1,2,3,6,13,16	10.00	Other
Assignment	Project Design Plan	2,3,6,7,8,9,12,13	0.01	Other
Report(s)	Research log	1,2,6,7,9,10,11,13,14	5.00	Other
Performance evaluation	Supervisor assessment of Project Management	3,6,8,9,12	4.99	Other
Oral Examination	Project Portfolio: Final Oral Examination	1,2,3,8,9,11,13,15	10.00	Other
Portfolio	Project Portfolio: Research Paper and Appendices	1,2,3,4,5,6,7,10,11,13,14,15,17,18	60.00	Other

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE580: Masters Project-IoT Major (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Directed learning	Preparation for Research Methodologies MCQ	6
Directed learning	Literature Review	94
Directed learning	Presentation Preparation & Delivery	30
Directed learning	Project Implementation Activities over Semesters 1+2	30
Directed learning	Semester 2 Project Planning	60
Independent Study	Independent Implementation during Summer Period	380
Directed learning	Final Implementation Elements in Summer Period	75
Report	Final Portfolio Production & Assessment	75
	Total Hours	750.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Adedeji B. Badiru, *Project management for research: A guide for Engineering and Science*, Springer [ISBN: 0412588900]
Supplementary / Recommended Book Resources
Thomas Mann 2005, *The Oxford guide to library research*, Oxford University Press New York [ISBN: 0195189981] **Hoang Pham, ed 2006, *Springer Handbook of Engineering Statistics*, Springer London [ISBN: 1852338067]** **Mike W. Martin, Roland Schinzinger 2005, *Ethics in engineering*, McGraw-Hill Boston [ISBN: 0072831154]** **Charles Lessard,, *Project Management for Engineering Design* [ISBN: 1598291742]**
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Marissa Condon	75059878
Semester 2	Marissa Condon	75059878
Autumn	Marissa Condon	75059878

Module Teachers	
Staff Member	*Staff Email*
Conor McArdle	Conor.McArdle@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Marissa Condon	Marissa.Condon@dcu.ie

EE581: Masters Project-Nano Tech. Major (Semester:1 Core)

Title:	Masters Project-Nano Tech. Major APPROVED
Long Title:	Masters Project - Nano Tech. Major
Language of Instruction:	English

Module Code:	EE581

Credits:	30

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Jennifer McManis

Module Coordinator:	Marissa Condon

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To allow the student to put theoretical knowledge of engineering to use in a practical project related to Nano Technology and related devices and to document the project outputs to research publication standard. In this module students will use and develop knowledge and skills in planning and managing projects, risk and health & safety assessments, reviewing literature, analysing, defining and implementing an engineering solution, documenting and presenting outcomes and key findings.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe and explain the scientific principles and engineering technologies and design processes associated with their project area
LO2	Identify engineering problems and to formulate problems in a manner which allows solution
LO3	Display a level of ingenuity in applying appropriate existing solutions or devising novel solutions to engineering design problems
LO4	Devise appropriate tests or experiments in order to allow exploration, analysis and evaluation of a proposed system design
LO5	Apply critical analysis to the results of tests or experiments and to draw concrete conclusions as to the effectiveness of an engineering design
LO6	Identify technical requirements for a design and to assess the practicality of possible solutions to problems arising in the project
LO7	Write well structured engineering reports which are written to the correct level of technical detail to suit the intended reader
LO8	Apply project management techniques in the execution of the project in order to undertake all project implementation and development work and to produce a complete project report to deadline
LO9	Take responsibility for progression of their own work under guidance of a supervisor and to identify and report problems and issues as they arise which might impede progress of a project
LO10	Conduct the required background research related to the project topic and be able to search for, access, review and evaluate publications on given topics
LO11	Distinguish between their own work and that of others and to credit others' in a proper manner
LO12	Resolve differences of opinion on technical matters between themselves and their supervisor
LO13	Effectively communicate technical concepts and ideas orally, in writing and graphically
LO14	Search research journals, the Internet, and other resources for relevant research approaches and to evaluate and compare these
LO15	Use statistical approaches, critical analysis, quantitative and qualitative comparisons to evaluate the quality of their own work and that of others
LO16	Communicate complex technical ideas to a lay audience
LO17	Report their research results to publication standard in the format of an academic paper
LO18	Document their results in a hierarchical manner, with fine detail delegated to appendices and key points in the main report

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE581: Masters Project-Nano Tech. Major
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Research Training Participation in research training activities in support of the literature review task.
Literature Review & Analysis of the Problem Conduct a critical analysis of the state-of-the-art research and engineering technologies relevant to the project problem to identify suitable, well-founded solution approaches. Maintenance of a student Research Log on an ongoing basis, capturing key findings and conclusions from reading of literature
Presentation Preparation & Delivery Presentation of key information, ideas and conclusions from the literature review and problem analysis, reporting progress on preliminary project design, evaluation of suitable methods, tools and technologies for implementation, experimentation, testing.
Project Plan Development of an approved solution method and detailed project plan for completing a well-grounded engineering implementation that will fulfill the project objectives.
Implementation of Solution Activities carried out to implement the project plan. May take many forms – system implementation and testing, experimental laboratory work, computer based modelling and analysis, etc.
Testing & Analysis of Results Designing appropriate tests and evaluating the outcome from these. Identifying and assessing new knowledge developed during the project in a critical and insightful manner.
Documentation of Outcomes Production of a conference paper documenting the solution approach, its relation to the state-of-the-art, results obtained and key findings and conclusions from the project outputs. Compiling a portfolio of supporting appendix materials. Attendance at final project interview with project assessors.
Communications with supervisor, technical support & others Arranged communications to discuss the advancement of the project and the technical resources required.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	Research Methodologies MCQ	10,11,14	1.00	Other
Report(s)	Literature Review	1,2,6,7,9,10,11,13,14	9.00	Other
Presentation	Oral Presentation	1,2,3,6,13,16	10.00	Other
Assignment	Project Design Plan	2,3,6,7,8,9,12,13	0.01	Other
Report(s)	Research Log	1,2,6,7,9,10,11,13,14	5.00	Other
Performance evaluation	Supervisor assessment of Project Management	3,6,8,9,12	4.99	Other
Oral Examination	Project Portfolio: Final Oral Examination	1,2,3,8,9,11,13,15	10.00	Other
Portfolio	Project Portfolio: Research Paper and Appendices	1,2,3,4,5,6,7,10,11,13,14,15,17,18	60.00	Other

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE581: Masters Project-Nano Tech. Major (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Directed learning	Preparation for Research Methodologies MCQ	6
Directed learning	Literature Review	94
Directed learning	Presentation Preparation & Delivery	30
Directed learning	Project Implementation Activities over Semesters 1+2	30
Directed learning	Semester 2 Project Planning	60
Independent Study	Independent Implementation during Summer Period	380
Directed learning	Final Implementation Elements in Summer Period	75
Report	Final Portfolio Production & Assessment	75
	Total Hours	750.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Adedeji B. Badiru, *Project management for research: A guide for Engineering and Science*, Springer [ISBN: 0412588900]
Supplementary / Recommended Book Resources
Thomas Mann 2005, *The Oxford guide to library research*, Oxford University Press New York [ISBN: 0195189981] **Hoang Pham, ed 2006, *Springer Handbook of Engineering Statistics*, Springer London [ISBN: 1852338067]** **Mike W. Martin, Roland Schinzinger 2005, *Ethics in engineering*, McGraw-Hill Boston [ISBN: 0072831154]** **Charles Lessard,, *Project Management for Engineering Design* [ISBN: 1598291742]**
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Marissa Condon	75059878
Semester 2	Marissa Condon	75059878
Autumn	Marissa Condon	75059878

Module Teachers	
Staff Member	*Staff Email*
Conor McArdle	Conor.McArdle@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Marissa Condon	Marissa.Condon@dcu.ie

EE582: Masters Project - SPT Major
(Semester:1 Core)

Title:	Masters Project - SPT Major APPROVED
Long Title:	Masters Project - Semiconductor and Plasma Technology Major
Language of Instruction:	English

Module Code:	EE582

Credits:	30

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	no programmes

Administrator:	Noel Murphy

Module Coordinator:	Marissa Condon

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To allow the student to put theoretical knowledge of engineering to use in a practical project related to Semiconductor and Plasma Technology and to document the project outputs to research publication standard. In this module students will use and develop knowledge and skills in planning and managing projects, risk and health & safety assessments, reviewing literature, analysing, defining and implementing an engineering solution, documenting and presenting outcomes and key findings.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe and explain the scientific principles and engineering technologies and design processes associated with their project area.
LO2	Identify engineering problems and to formulate problems in a manner which allows solution.
LO3	Display a level of ingenuity in applying appropriate existing solutions or devising novel solutions to engineering design problems.
LO4	Devise appropriate tests or experiments in order to allow exploration, analysis and evaluation of a proposed system design.
LO5	Apply critical analysis to the results of tests or experiments and to draw concrete conclusions as to the effectiveness of an engineering design.
LO6	Identify technical requirements for a design and to assess the practicality of possible solutions to problems arising in the project
LO7	Write well-structured engineering reports which are written to the correct level of technical detail to suit the intended reader
LO8	Apply project management techniques in the execution of the project in order to undertake all project implementation and development work and to produce a complete project report to deadline.
LO9	Take responsibility for progression of their own work under guidance of a supervisor and to identify and report problems and issues as they arise which might impede progress of a project.
LO10	Conduct the required background research related to the project topic and be able to search for, access, review and evaluate publications on given topics.
LO11	Distinguish between their own work and that of others and to credit others' in a proper manner.
LO12	Resolve differences of option on technical matters between themselves and their supervisor.
LO13	Effectively communicate technical concepts and ideas orally, in writing and graphically.
LO14	Search research journals, the Internet, and other resources for relevant research approaches and to evaluate and compare these.
LO15	Use statistical approaches, critical analysis, quantitative and qualitative comparisons to evaluate the quality of their own work and that of others.
LO16	Communicate complex technical ideas to a lay audience.
LO17	Report their research results to publication standard in the format of an academic paper.
LO18	Document their results in a hierarchical manner, with fine detail delegated to appendices and key points in the main report.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE582: Masters Project - SPT Major
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Research Training Participation in research training activities in support of the literature review task.
Literature Review & Analysis of the Problem Conducting a critical analysis of the state-of-the-art research and engineering technologies relevant to the project problem to identify suitable, well-founded solution approaches. Maintenance of a student Research Log on an ongoing basis, capturing key findings and conclusions from reading of literature.
Presentation Preparation & Delivery Presentation of key information, ideas and conclusions from the literature review and problem analysis, reporting progress on preliminary project design, evaluation of suitable methods, tools and technologies for implementation, experimentation, testing.
Project Plan Development of an approved solution method and detailed project plan for completing a well-grounded engineering implementation that will fulfill the project objectives.
Implementation of Solution Activities carried out to implement the project plan. May take many forms – system implementation and testing, experimental laboratory work, computer based modelling and analysis, etc.
Testing & Analysis of Results Designing appropriate tests and evaluating the outcome from these. Identifying and assessing new knowledge developed during the project in a critical and insightful manner.
Documentation of Outcomes Production of a conference paper documenting the solution approach, its relation to the state-of-the-art, results obtained and key findings and conclusions from the project outputs. Compiling a portfolio of supporting appendix materials. Attendance at final project interview with project assessors.
Communications with supervisor, technical support & others Arranging communications (on-campus and/or electronic) to discuss the progress of the project and to organise any required technical resources and materials.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	Research Methodologies MCQ	10,11,14	1.00	Week 8
Research Paper	Literature Review	1,2,6,7,9,10,11,13,14	9.00	Week 19
Presentation	Oral Presentation	1,2,3,6,13,16	10.00	Week 24
Assignment	Project Design Plan	2,3,6,7,8,9,12,13	0.01	Other
Report(s)	Research Log	1,2,6,7,9,10,11,13,14	5.00	Other
Performance evaluation	Supervisor assessment of Project Management	3,6,8,9,12	4.99	Other
Oral Examination	Project Portfolio: Final Oral Examination	1,2,3,8,9,11,13,15	10.00	Other
Portfolio	Project Portfolio: Research Paper and Appendices	1,2,3,4,5,6,7,10,11,13,14,15,17,18	60.00	Other

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE582: Masters Project - SPT Major
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Directed learning	Preparation for Research Methodologies MCQ	6
Directed learning	Literature Review	94
Directed learning	Presentation Preparation & Delivery	30
Directed learning	Project Implementation Activities over Semesters 1+2	30
Directed learning	Semester 2 Project Planning	60
Independent Study	Independent Implementation during Summer Period	380
Directed learning	Final Implementation Elements in Summer Period	75
Report	Final Portfolio Production & Assessment	75
	Total Hours	750.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Adedeji B. Badiru, *Project management for research: A guide for Engineering and Science*, Springer [ISBN: 0412588900]
Supplementary / Recommended Book Resources
Richard Bullock, Michal Brody, Francine Weinberg 2016, *The Little Seagull Handbook*, 3 Ed., W. W. Norton & Company [ISBN: 978-039360263] **Thomas Mann 2005, *The Oxford guide to library research*, Oxford University Press New York [ISBN: 0195189981]** **Hoang Pham, ed 2006, *Springer Handbook of Engineering Statistics*, Springer [ISBN: 1852338067]** **Mike W. Martin, Roland Schinzinger 2005, *Ethics in engineering*, McGraw-Hill [ISBN: 0072831154]** **Charles Lessard, *Project Management for Engineering Design* [ISBN: 1598291742]**
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Marissa Condon	75059878
Semester 2	Marissa Condon	75059878
Autumn	Marissa Condon	75059878

Module Teachers	
Staff Member	*Staff Email*
Paul Swift	Paul.Swift@dcu.ie
Conor McArdle	Conor.McArdle@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Marissa Condon	Marissa.Condon@dcu.ie

EE583: Masters Project - FNT Major
(Semester:1 Core)

Title:	Masters Project - FNT Major APPROVED
Long Title:	Masters Project - Future Network Technologies Major
Language of Instruction:	English

Module Code:	EE583

Credits:	30

NFQ Level:	9

Field of Study:	Electronic Engineering

moduleLearningOutcomeTaxonomy:	Blooms

Module Delivered In	no programmes

Administrator:	Jennifer McManis

Module Coordinator:	Marissa Condon

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To allow the student to put theoretical knowledge of engineering to use in a practical project related to Future Network Technologies and to document the project outputs to research publication standard. In this module students will use and develop knowledge and skills in planning and managing projects, risk and health & safety assessments, reviewing literature, analysing, defining and implementing an engineering solution, documenting and presenting outcomes and key findings.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe and explain the scientific principles and engineering technologies and design processes associated with their project area
LO2	Identify engineering problems and to formulate problems in a manner which allows solution
LO3	Display a level of ingenuity in applying appropriate existing solutions or devising novel solutions to engineering design problems
LO4	Devise appropriate tests or experiments in order to allow exploration, analysis and evaluation of a proposed system design
LO5	Apply critical analysis to the results of tests or experiments and to draw concrete conclusions as to the effectiveness of an engineering design
LO6	Identify technical requirements for a design and to assess the practicality of possible solutions to problems arising in the project
LO7	Write well structured engineering reports which are written to the correct level of technical detail to suit the intended reader
LO8	Apply project management techniques in the execution of the project in order to undertake all project implementation and development work and to produce a complete project report to deadline
LO9	Take responsibility for progression of their own work under guidance of a supervisor and to identify and report problems and issues as they arise which might impede progress of a project
LO10	Conduct the required background research related to the project topic and be able to search for, access, review and evaluate publications on given topics
LO11	Distinguish between their own work and that of others and to credit others' in a proper manner
LO12	Resolve differences of opinion on technical matters between themselves and their supervisor
LO13	Effectively communicate technical concepts and ideas orally, in writing and graphically
LO14	Search research journals, the Internet, and other resources for relevant research approaches and to evaluate and compare these
LO15	Use statistical approaches, critical analysis, quantitative and qualitative comparisons to evaluate the quality of their own work and that of others
LO16	Communicate complex technical ideas to a lay audience
LO17	Report their research results to publication standard in the format of an academic paper
LO18	Document their results in a hierarchical manner, with fine detail delegated to appendices and key points in the main report

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE583: Masters Project - FNT Major
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Research Training Participation in research training activities in support of the literature review task.
Literature Review & Analysis of the Problem Conduct a critical analysis of the state-of-the-art research and engineering technologies relevant to the project problem to identify suitable, well-founded solution approaches. Maintenance of a student Research Log on an ongoing basis, capturing key findings and conclusions from reading of literature.
Presentation Preparation & Delivery Presentation of key information, ideas and conclusions from the literature review and problem analysis, reporting progress on preliminary project design, evaluation of suitable methods, tools and technologies for implementation, experimentation, testing.
Project Plan Development of an approved solution method and detailed project plan for completing a well-grounded engineering implementation that will fulfill the project objectives.
Implementation of Solution Activities carried out to implement the project plan. May take many forms – system implementation and testing, experimental laboratory work, computer based modelling and analysis, etc.
Testing & Analysis of Results Designing appropriate tests and evaluating the outcome from these. Identifying and assessing new knowledge developed during the project in a critical and insightful manner.
Documentation of Outcomes Production of a conference paper documenting the solution approach, its relation to the state-of-the-art, results obtained and key findings and conclusions from the project outputs. Compiling a portfolio of supporting appendix materials. Attendance at final project interview with project assessors.
Communications with supervisor, technical support & others Arranged communications to discuss the advancement of the project and the technical resources required.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	Research Methodologies MCQ	10,11,14	1.00	Other
Research Paper	Literature Review	1,2,6,7,9,10,11,13,14	9.00	Other
Presentation	Oral Presentation	1,2,3,6,13,16	10.00	Other
Assignment	Project Design Plan	2,3,6,7,8,9,12,13	0.01	Other
Report(s)	Research log	1,2,6,7,9,10,11,13,14	5.00	Other
Performance evaluation	Supervisor assessment of Project Management	3,6,8,9,12	4.99	Other
Oral Examination	Project Portfolio: Final Oral Examination	1,2,3,8,9,11,13,15	10.00	Other
Portfolio	Project Portfolio: Research Paper and Appendices	1,2,3,4,5,6,7,10,11,13,14,15,17,18	60.00	Other

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE583: Masters Project - FNT Major
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Directed learning	Preparation for Research Methodologies MCQ	6
Directed learning	Literature Review	94
Directed learning	Presentation Preparation & Delivery	30
Directed learning	Project Implementation Activities over Semesters 1+2	30
Directed learning	Semester 2 Project Planning	60
Independent Study	Independent Implementation during Summer Period	380
Directed learning	Final Implementation Elements in Summer Period	75
Report	Final Portfolio Production & Assessment	75
	Total Hours	750.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Adedeji B. Badiru, *Project management for research: A guide for Engineering and Science*, Springer [ISBN: 0412588900]
Supplementary / Recommended Book Resources
Thomas Mann 2005, *The Oxford guide to library research*, Oxford University Press New York [ISBN: 0195189981] **Hoang Pham, ed 2006, *Springer Handbook of Engineering Statistics*, Springer London [ISBN: 1852338067]** **Mike W. Martin, Roland Schinzinger 2005, *Ethics in engineering*, McGraw-Hill Boston [ISBN: 0072831154]** **Charles Lessard,, *Project Management for Engineering Design* [ISBN: 1598291742]**
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Marissa Condon	75059878
Semester 2	Marissa Condon	75059878
Autumn	Marissa Condon	75059878

Module Teachers	
Staff Member	*Staff Email*
Conor McArdle	Conor.McArdle@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Marissa Condon	Marissa.Condon@dcu.ie

EE592: General Masters Project
(Semester:1 Core)

Title:	General Masters Project APPROVED
Long Title:	General Masters Project
Language of Instruction:	English

Module Code:	EE592

Credits:	30

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	8 programme(s)

Administrator:	Jennifer McManis

Module Coordinator:	Marissa Condon

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To allow the student to put theoretical knowledge of engineering to use in a practical project related to Electronic and Computer-based systems and to document the project outputs to research publication standard. In this module students will use and develop knowledge and skills in planning and managing projects, risk and health & safety assessments, reviewing literature, analysing, defining and implementing an engineering solution, documenting and presenting outcomes and key findings.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe and explain the scientific principles and engineering technologies and design processes associated with their project area
LO2	Identify engineering problems and to formulate problems in a manner which allows solution
LO3	Display a level of ingenuity in applying appropriate existing solutions or devising novel solutions to engineering design problems
LO4	Devise appropriate tests or experiments in order to allow exploration, analysis and evaluation of a proposed system design
LO5	Apply critical analysis to the results of tests or experiments and to draw concrete conclusions as to the effectiveness of an engineering design
LO6	Identify technical requirements for a design and to assess the practicality of possible solutions to problems arising in the project
LO7	Write well structured engineering reports which are written to the correct level of technical detail to suit the intended reader
LO8	Apply project management techniques in the execution of the project in order to undertake all project implementation and development work and to produce a complete project report to deadline
LO9	Take responsibility for progression of their own work under guidance of a supervisor and to identify and report problems and issues as they arise which might impede progress of a project
LO10	Conduct the required background research related to the project topic and be able to search for, access, review and evaluate publications on given topics
LO11	Distinguish between their own work and that of others and to credit others' in a proper manner
LO12	Resolve differences of opinion on technical matters between themselves and their supervisor
LO13	Effectively communicate technical concepts and ideas orally, in writing and graphically
LO14	Search research journals, the Internet, and other resources for relevant research approaches and to evaluate and compare these
LO15	Use statistical approaches, critical analysis, quantitative and qualitative comparisons to evaluate the quality of their own work and that of others
LO16	Communicate complex technical ideas to a lay audience
LO17	Report their research results to publication standard in the format of an academic paper
LO18	Document their results in a hierarchical manner, with fine detail delegated to appendices and key points in the main report

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE592: General Masters Project
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Research Training Participation in research training activities in support of the literature review task.
Literature Review & Analysis of the Problem Conduct a critical analysis of the state-of-the-art research and engineering technologies relevant to the project problem to identify suitable, well-founded solution approaches. Maintenance of a student Research Log on an ongoing basis, capturing key findings and conclusions from reading of literature
Presentation Preparation & Delivery Presentation of key information, ideas and conclusions from the literature review and problem analysis, reporting progress on preliminary project design, evaluation of suitable methods, tools and technologies for implementation, experimentation, testing.
Project Plan Development of an approved solution method and detailed project plan for completing a well-grounded engineering implementation that will fulfill the project objectives.
Implementation of Solution Activities carried out to implement the project plan. May take many forms – system implementation and testing, experimental laboratory work, computer based modelling and analysis, etc.
Testing & Analysis of Results Designing appropriate tests and evaluating the outcome from these. Identifying and assessing new knowledge developed during the project in a critical and insightful manner.
Documentation of Outcomes Production of a conference paper documenting the solution approach, its relation to the state-of-the-art, results obtained and key findings and conclusions from the project outputs. Compiling a portfolio of supporting appendix materials. Attendance at final project interview with project assessors.
Communications with supervisor, technical support & others Arranged communications to discuss the advancement of the project and the technical resources required.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	Research Methodologies MCQ	10,11,14	1.00	Other
Research Paper	Literature Review	1,2,6,7,9,10,11,13,14	9.00	Other
Presentation	Oral Presentation	1,2,3,6,13,16	10.00	Other
Assignment	Project design plan	2,3,6,7,8,9,12,13	0.01	Other
Report(s)	Research Log	1,2,6,7,9,10,11,13,14	5.00	Other
Performance evaluation	Supervisor assessment of Project Management	3,6,8,9,12	4.99	Other
Oral Examination	Project Portfolio: Final Oral Examination	1,2,3,8,9,11,13,15	10.00	Other
Portfolio	Project Portfolio: Research Paper and appendices	1,2,3,4,5,6,7,10,11,13,14,15,17,18	60.00	Other

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE592: General Masters Project
(Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Directed learning	Preparation for Research Methodologies MCQ	6
Directed learning	Literature Review	94
Directed learning	Presentation Preparation & Delivery	30
Directed learning	Project Implementation Activities over Semester 1 and 2.	30
Directed learning	Semester 2 Project Planning	60
Independent Study	Independent Implementation over the Summer period.	380
Directed learning	Final Implementation Elements in Summer period.	75
Report	Final Portfolio Production & Assessment	75
	Total Hours	750.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Adedeji B. Badiru, *Project management for research: A guide for Engineering and Science*, Springer [ISBN: 0412588900]
Supplementary / Recommended Book Resources
Thomas Mann 2005, *The Oxford guide to library research*, Oxford University Press New York [ISBN: 0195189981] **Hoang Pham, ed 2006, *Springer Handbook of Engineering Statistics*, Springer London [ISBN: 1852338067]** **Mike W. Martin, Roland Schinzinger 2005, *Ethics in engineering*, McGraw-Hill Boston [ISBN: 0072831154]** **Charles Lessard,, *Project Management for Engineering Design* [ISBN: 1598291742]**
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Marissa Condon	75059878
Semester 2	Marissa Condon	75059878
Autumn	Marissa Condon	75059878

Module Teachers	
Staff Member	*Staff Email*
Conor McArdle	Conor.McArdle@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Marissa Condon	Marissa.Condon@dcu.ie

EE595: Masters Project-IPA Major
(Semester:1 Core)

Title:	Masters Project-IPA Major APPROVED
Long Title:	Masters Project - IPA Major
Language of Instruction:	English

Module Code:	EE595

Credits:	30

NFQ Level:	9

Field of Study:	Electronic Engineering

Module Delivered In	8 programme(s)

Administrator:	Jennifer McManis

Module Coordinator:	Marissa Condon

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To allow the student to put theoretical knowledge of engineering to use in a practical project related to Image Processing Applications and to document the project outputs to research publication standard. In this module students will use and develop knowledge and skills in planning and managing projects, risk and health & safety assessments, reviewing literature, analysing, defining and implementing an engineering solution, documenting and presenting outcomes and key findings.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe and explain the scientific principles and engineering technologies and design processes associated with their project area
LO2	Identify engineering problems and to formulate problems in a manner which allows solution
LO3	Display a level of ingenuity in applying appropriate existing solutions or devising novel solutions to engineering design problems
LO4	Devise appropriate tests or experiments in order to allow exploration, analysis and evaluation of a proposed system design
LO5	Apply critical analysis to the results of tests or experiments and to draw concrete conclusions as to the effectiveness of an engineering design
LO6	Identify technical requirements for a design and to assess the practicality of possible solutions to problems arising in the project
LO7	Write well structured engineering reports which are written to the correct level of technical detail to suit the intended reader
LO8	Apply project management techniques in the execution of the project in order to undertake all project implementation and development work and to produce a complete project report to deadline
LO9	Take responsibility for progression of their own work under guidance of a supervisor and to identify and report problems and issues as they arise which might impede progress of a project
LO10	Conduct the required background research related to the project topic and be able to search for, access, review and evaluate publications on given topics
LO11	Distinguish between their own work and that of others and to credit others' in a proper manner
LO12	Resolve differences of opinion on technical matters between themselves and their supervisor
LO13	Effectively communicate technical concepts and ideas orally, in writing and graphically
LO14	Search research journals, the Internet, and other resources for relevant research approaches and to evaluate and compare these
LO15	Use statistical approaches, critical analysis, quantitative and qualitative comparisons to evaluate the quality of their own work and that of others
LO16	Communicate complex technical ideas to a lay audience
LO17	Report their research results to publication standard in the format of an academic paper
LO18	Document their results in a hierarchical manner, with fine detail delegated to appendices and key points in the main report

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE595: Masters Project-IPA Major
(Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Research Training Participation in research training activities in support of the literature review task.
Literature Review & Analysis of the Problem Conducting a critical analysis of the state-of-the-art research and engineering technologies relevant to the project problem to identify suitable, well-founded solution approaches. Maintenance of a student Research Log on an ongoing basis, capturing key findings and conclusions from reading of literature.
Presentation Preparation & Delivery Presentation of key information, ideas and conclusions from the literature review and problem analysis, reporting progress on preliminary project design, evaluation of suitable methods, tools and technologies for implementation, experimentation, testing.
Project Plan Development of an approved solution method and detailed project plan for completing a well-grounded engineering implementation that will fulfill the project objectives.
Implementation of Solution Activities carried out to implement the project plan. May take many forms – system implementation and testing, experimental laboratory work, computer based modelling and analysis, etc.
Testing & Analysis of Results Designing appropriate tests and evaluating the outcome from these. Identifying and assessing new knowledge developed during the project in a critical and insightful manner.
Documentation of Outcomes Production of a conference paper documenting the solution approach, its relation to the state-of-the-art, results obtained and key findings and conclusions from the project outputs. Compiling a portfolio of supporting appendix materials. Attendance at final project interview with project assessors.
Communications with supervisor, technical support & others Arranged communications to discuss the advancement of the project and the technical resources required.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	Research Methodologies MCQ	10,11,14	1.00	Other
Research Paper	Literature Review	1,2,6,7,9,10,11,13,14	9.00	Other
Presentation	Oral Presentation	1,2,3,6,13,16	10.00	Other
Assignment	Project Design Plan	2,3,6,7,8,9,12,13	0.01	Other
Report(s)	Research Log	1,2,6,7,9,10,11,13,14	5.00	Other
Performance evaluation	Supervisor assessment of Project Management	3,6,8,9,12	4.99	Other
Oral Examination	Project Portfolio: Final Oral Examination	1,2,3,8,9,11,13,15	10.00	Other
Portfolio	Project Portfolio: Research Paper and Appendices	1,2,3,4,5,6,7,10,11,13,14,15,17,18	60.00	Other

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE595: Masters Project-IPA Major (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Directed learning	Preparation for Research Methodologies MCQ	6
Directed learning	Literature Review	94
Directed learning	Presentation Preparation & Delivery	30
Directed learning	Project Implementation Activities over Semesters 1+2	30
Directed learning	Semester 2 Project Planning	60
Independent Study	Independent Implementation during Summer Period	380
Directed learning	Final Implementation Elements in Summer Period	75
Report	Final Portfolio Production & Assessment	75
	Total Hours	750.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Adedeji B. Badiru, *Project management for research: A guide for Engineering and Science*, Springer [ISBN: 0412588900]
Supplementary / Recommended Book Resources
Thomas Mann 2005, *The Oxford guide to library research*, Oxford University Press New York [ISBN: 0195189981] **Hoang Pham, ed 2006, *Springer Handbook of Engineering Statistics*, Springer London [ISBN: 1852338067]** **Mike W. Martin, Roland Schinzinger 2005, *Ethics in engineering*, McGraw-Hill Boston [ISBN: 0072831154]** **Charles Lessard,, *Project Management for Engineering Design* [ISBN: 1598291742]**
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Marissa Condon	75059878
Semester 2	Marissa Condon	75059878
Autumn	Marissa Condon	75059878

Module Teachers	
Staff Member	*Staff Email*
Conor McArdle	Conor.McArdle@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Marissa Condon	Marissa.Condon@dcu.ie

EE596: Masters Project-Network Major (Semester:1 Core)

Title:	Masters Project-Network Major APPROVED
Long Title:	Masters Project - Networks Major
Language of Instruction:	English

Module Code:	EE596

Credits:	30

NFQ Level:	9

Field of Study:	Communication Technologies

Module Delivered In	8 programme(s)

Administrator:	Jennifer McManis

Module Coordinator:	Marissa Condon

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	To allow the student to put theoretical knowledge of engineering to use in a practical project related to Telecommunications Network design, analysis and engineering and to document the project outputs to research publication standard. In this module students will use and develop knowledge and skills in planning and managing projects, risk and health & safety assessments, reviewing literature, analysing, defining and implementing an engineering solution, documenting and presenting outcomes and key findings.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Describe and explain the scientific principles and engineering technologies and design processes associated with their project area
LO2	Identify engineering problems and to formulate problems in a manner which allows solution
LO3	Display a level of ingenuity in applying appropriate existing solutions or devising novel solutions to engineering design problems
LO4	Devise appropriate tests or experiments in order to allow exploration, analysis and evaluation of a proposed system design
LO5	Apply critical analysis to the results of tests or experiments and to draw concrete conclusions as to the effectiveness of an engineering design
LO6	Identify technical requirements for a design and to assess the practicality of possible solutions to problems arising in the project
LO7	Write well structured engineering reports which are written to the correct level of technical detail to suit the intended reader
LO8	Apply project management techniques in the execution of the project in order to undertake all project implementation and development work and to produce a complete project report to deadline
LO9	Take responsibility for progression of their own work under guidance of a supervisor and to identify and report problems and issues as they arise which might impede progress of a project
LO10	Conduct the required background research related to the project topic and be able to search for, access, review and evaluate publications on given topics
LO11	Distinguish between their own work and that of others and to credit others' in a proper manner
LO12	Resolve differences of opinion on technical matters between themselves and their supervisor
LO13	Effectively communicate technical concepts and ideas orally, in writing and graphically
LO14	Search research journals, the Internet, and other resources for relevant research approaches and to evaluate and compare these
LO15	Use statistical approaches, critical analysis, quantitative and qualitative comparisons to evaluate the quality of their own work and that of others
LO16	Communicate complex technical ideas to a lay audience
LO17	Report their research results to publication standard in the format of an academic paper
LO18	Document their results in a hierarchical manner, with fine detail delegated to appendices and key points in the main report

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*

EE596: Masters Project- Network Major (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Research Training Participation in research training activities in support of the literature review task.
Literature Review & Analysis of the Problem Conduct a critical analysis of the state-of-the-art research and engineering technologies relevant to the project problem to identify suitable, well-founded solution approaches. Maintenance of a student Research Log on an ongoing basis, capturing key findings and conclusions from reading of literature
Presentation Preparation & Delivery Presentation of key information, ideas and conclusions from the literature review and problem analysis, reporting progress on preliminary project design, evaluation of suitable methods, tools and technologies for implementation, experimentation, testing.
Project Plan Development of an approved solution method and detailed project plan for completing a well-grounded engineering implementation that will fulfill the project objectives.
Implementation of Solution Activities carried out to implement the project plan. May take many forms – system implementation and testing, experimental laboratory work, computer based modelling and analysis, etc.
Testing & Analysis of Results Designing appropriate tests and evaluating the outcome from these. Identifying and assessing new knowledge developed during the project in a critical and insightful manner.
Documentation of Outcomes Production of a conference paper documenting the solution approach, its relation to the state-of-the-art, results obtained and key findings and conclusions from the project outputs. Compiling a portfolio of supporting appendix materials. Attendance at final project interview with project assessors.
Communications with supervisor, technical support & others Arranged communications to discuss the advancement of the project and the technical resources required.

Assessment Breakdown	%
Continuous Assessment	100.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	Research Methodologies MCQ	10,11,14	1.00	Other
Report(s)	Literature Review	1,2,6,7,9,10,11,13,14	9.00	Other
Presentation	Oral Presentation	1,2,3,6,13,16	10.00	Other
Assignment	Project Design Plan	2,3,6,7,8,9,12,13	0.01	Other
Report(s)	Research Log	1,2,6,7,9,10,11,13,14	5.00	Other
Performance evaluation	Supervisor assessment of Project Management	3,6,8,9,12	4.99	Other
Oral Examination	Project Portfolio: Final Oral Examination	1,2,3,8,9,11,13,15	10.00	Other
Portfolio	Project Portfolio: Research Paper, Appendices	1,2,3,4,5,6,7,10,11,13,14,15,17,18	60.00	Other

No End of Module Formal Examination

DCU reserves the right to alter the nature and timings of assessment

EE596: Masters Project-Network Major (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Directed learning	Preparation for Research Methodologies MCQ	6
Directed learning	Literature Review	94
Directed learning	Presentation Preparation & Delivery	30
Directed learning	Project Implementation Activities over Semesters 1+2	30
Directed learning	Semester 2 Project Planning	60
Independent Study	Independent Implementation during Summer Period	380
Directed learning	Final Implementation Elements in Summer Period	75
Report	Final Portfolio Production & Assessment	75
	Total Hours	750.00

This module has no Part Time workload.

Module Resources

Essential Book Resources
Adedeji B. Badiru, *Project management for research: A guide for Engineering and Science*, Springer [ISBN: 0412588900]
Supplementary / Recommended Book Resources
Thomas Mann 2005, *The Oxford guide to library research*, Oxford University Press New York [ISBN: 0195189981] **Hoang Pham, ed 2006, *Springer Handbook of Engineering Statistics*, Springer London [ISBN: 1852338067]** **Mike W. Martin, Roland Schinzinger 2005, *Ethics in engineering*, McGraw-Hill Boston [ISBN: 0072831154]** **Charles Lessard,, *Project Management for Engineering Design* [ISBN: 1598291742]**
This module does not have any article/paper resources
This module does not have any other resources

Module Delivered In

Programme Code	Programme	Semester	Delivery
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option
MEN	MEng in Electronic Systems	1	Option

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Marissa Condon	75059878
Semester 2	Marissa Condon	75059878
Autumn	Marissa Condon	75059878

Module Teachers	
Staff Member	*Staff Email*
Conor McArdle	Conor.McArdle@dcu.ie
Jennifer Bruton	Jennifer.Bruton@dcu.ie
Marissa Condon	Marissa.Condon@dcu.ie

PS508A: Fundamentals of Industrial Plasmas (Semester:1 Core)

Title:	Fundamentals of Industrial Plasmas APPROVED
Long Title:	Fundamentals of Industrial Plasmas A
Language of Instruction:	English

Module Code:	PS508A

Credits:	7.5

NFQ Level:	9

Field of Study:	Physics

Module Delivered In	no programmes

Administrator:	Eamonn Cunningham

Module Coordinator:	Paul Swift

moduledepartment:	32 - PHYSICAL SCIENCES

Module Description:	The purpose of this module is to present the fundamental principles of partially ionised, chemically active plasma discharges and their use in surface processing and other industrial applications. Introduce plasma behaviour by drawing on examples from nature and by pointing out specific plasma properties which are useful in technological applications. Provide an introduction to plasma measurement techniques and to the basic interactions between plasmas and surfaces.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Develop and articulate an understanding of knowledge at the forefront of research both qualitatively, and, where appropriate, quantitatively, of the distinguishing features of a plasma.
LO2	Demonstrate the ability to identify the critical plasma parameters pertaining to industrial plasmas.
LO3	Demonstrate the ability to evaluate the importance of plasmas in industry.
LO4	Demonstrate the knowledge required to identify the requirements for plasma generation and characterisation.
LO5	Demonstrate the ability to apply physical principles in order to solve written numerical problems.
LO6	Demonstrate the ability to communicate the concepts, methods and ideas studied in this module with their peers via online discussion groups.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
Entry requirements to Masters study in field will suffice.

PS508A: Fundamentals of Industrial Plasmas (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Indicative Syllabus Definition of a plasma: Relevant concepts from gas (kinetic) theory. Charged particle interactions. Collective phenomena and Debye shielding. Ambipolar diffusion and plasma sheaths. Plasma chemistry: Collisions and cross sections. Plasma composition. Plasma generation: Non-equilibrium and energy transport. Plasma formation and decay. Plasma properties: Particle and energy balance. Scaling laws. Industrial applications: Discussion of certain applications, and the properties of plasma that are most relevant to those applications.

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	5 Quizzes	1,2,3,4,5	15.00	n/a
Participation	On-line participation in discussion groups	1,2,3,4,5,6	10.00	n/a

End of Module Formal Examination

Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	2 hour formal examination	1,2,3,4,5	75.00	End-of-Semester

Reassessment Pre-Requisite
Repeat examination *Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.*
Reassessment Description Repeat examination available in August

DCU reserves the right to alter the nature and timings of assessment

PS508A: Fundamentals of Industrial Plasmas (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Directed learning	Study of online course material	75
Directed learning	Participation in online discussion groups	24
Assignment Completion	Study for, and completion of, 5 loop quizes	30
Independent Study	Study for final examination	58.5
	Total Hours	187.50

This module has no Part Time workload.

Module Resources

Essential Book Resources
M. A. Lieberman and A. J. Lichtenberg 2005, *Principles of Plasma Discharges and Materials Processing*, 2 Ed., John Wiley & Sons, [ISBN: 9780471720010]
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Paul Swift	80013872
Semester 2	Paul Swift	80013872
Autumn	Paul Swift	80013872

Module Teachers	
Staff Member	*Staff Email*
Paul Swift	Paul.Swift@dcu.ie

PS510A: Plasma Applications (Semester:1 Core)

Title:	Plasma Applications APPROVED
Long Title:	Plasma Applications A
Language of Instruction:	English

Module Code:	PS510A

Credits:	7.5

NFQ Level:	9

Field of Study:	Physics

Module Delivered In	no programmes

Administrator:	Eamonn Cunningham

Module Coordinator:	Paul Swift

moduledepartment:	32 - PHYSICAL SCIENCES

Module Description:	The purpose of this module is to provide an overview of the importance of plasma technology in the modern world and to give the students an awareness and appreciation of the ways in which applications of plasmas can enable the development of new manufacturing technologies and processes. The module deals in detail with the specific plasma surface interactions which determine the performance of processing technologies and examines the most important surface processing applications used in high technology industries, through a detailed treatment of specific examples.

Learning Outcomes	
On successful completion of this module the learner will be able to:	
LO1	Demonstrate the ability to recognise and explain the economic and environmental importance of modern application.
LO2	Demonstrate the ability to identify the technical aspects of plasma surface interactions and their impact on product quality.
LO3	Demonstrate the ability to recognise and critically evaluate the most important examples of plasma applications.
LO4	Demonstrate the ability to access and critically evaluate scientific literature dealing with plasma applications.
LO5	Demonstrate the ability to communicate the concepts, methods and ideas studied in this module with their peers via online discussion groups.

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
Entry requirements to Masters study in field will suffice.

PS510A: Plasma Applications (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
Indicative Syllabus Basic processes, reactions, simple kinetic models. Plasma Surface Interactions: Surface states and structure. Ion, electron and photon surface interactions. Surface chemical kinetics. Surface Processing: Activation (surface energy, wetability and adhesion). Sputtering (sputter etching, sputter deposition and reactive sputter deposition). Etching (including RIE and high density plasma etching), etching characteristics (anisotropy, residues, selectivity, uniformity, damage). Deposition of thin films, PECVD. Film properties and structure (hardness and other physical properties, amorphous films, plasma polymerisation, epitaxial growth, interface issues). Specific Examples: Detailed examples of plasma processes including the plasma surface interaction mechanisms. Examples may include fluorocarbon etching of silicon and SiO2, CH4+H2 diamond deposition, activation of polymers and plasma processing of natural and artificial fibers, deposition of bio-compatible thin films, deposition of metallic coatings and alloys, and/or others.

Assessment Breakdown	%
Continuous Assessment	25.00%
End of Academic Session	75.00%

Continuous Assessment				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Loop Quiz	5 Quizzes	1,2,3,4	15.00	n/a
Participation	On-line participation	1,2,3,4,5	10.00	n/a

End of Module Formal Examination				
Assessment Type	*Assessment Description*	*Outcome Addressed*	*% of total*	*Assessment Date*
Formal Examination	2 hour formal examination	1,2,3,4	75.00	End-of-Semester

Reassessment Pre-Requisite
Repeat examination *Reassessment of this module will consist of a repeat examination. It is possible that there will also be a requirement to be reassessed in a coursework element.*
Reassessment Description Repeat examination available in August

DCU reserves the right to alter the nature and timings of assessment

PS510A: Plasma Applications (Semester:1 Core)

Module Workload

Full Time hours per semester		
WorkLoad Type	*WorkLoad Description*	*Hours*
Assessment Feedback	Study of online course material	75
Directed learning	Participation in online discussion groups	24
Assignment Completion	Study for, and completion of, 5 loop quizes	30
Independent Study	Study for final examination	58.5
	Total Hours	187.50

This module has no Part Time workload.

Module Resources

Essential Book Resources
M. A. Lieberman and A. J. Lichtenberg 2005, *Principles of Plasma Discharges and Materials Processing*, 2 Ed., John Wiley & Sons [ISBN: 9780471720010]
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	Paul Swift	80013872
Semester 2	Paul Swift	80013872
Autumn	Paul Swift	80013872

Module Teachers	
Staff Member	*Staff Email*
Paul Swift	Paul.Swift@dcu.ie

EE522: ITSC Spare Module Code for EE (Semester:1 Core)

Title:	ITSC Spare Module Code for EE DRAFT
Long Title:	ITSC Spare Module Code for EE

Module Code:	EE522

Credits:	30

NFQ Level:	9

Field of Study:	

Module Delivered In	no programmes

Administrator:	Akari Software

Module Coordinator:	Akari Software

moduledepartment:	20 - ELECTRONIC ENGINEERING

Module Description:	no description provided

Learning Outcomes
No learning outcomes provided

Pre-requisite learning
Module Recommendations *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No recommendations listed
Co-requisite Modules
No Co-requisite modules listed
Pre-Requisite *This is prior learning (or a practical skill) that is mandatory before enrolment in this module is allowed. You may not enrol on this module if you have not acquired the learning specified in this section.*
No Pre-Requisites listed

EE522: ITSC Spare Module Code for EE (Semester:1 Core)

Module Content & Assessment

Indicative Content and Learning Activities
No indicative content

Assessment Breakdown	%
Continuous Assessment	100.00%

DCU reserves the right to alter the nature and timings of assessment

EE522: ITSC Spare Module Code for EE (Semester:1 Core)

Module Workload

This module has no Full Time workload.

This module has no Part Time workload.

Module Resources

This module does not have any book resources
This module does not have any article/paper resources
This module does not have any other resources

Module Managers & Teachers

Module Managers		
Semester	*Staff Member*	*Staff Number*
Semester 1	N/A	N/A
Semester 2	N/A	N/A
Autumn	N/A	N/A

Module Teachers	
Staff Member	*Staff Email*
No Teacher Staff Assigned	