H9QC: Quantum Computing

Module Code:	H9QC
Long Title	Quantum Computing APPROVED
Title	Quantum Computing
Module Level:	LEVEL 9
EQF Level:	7
EHEA Level:	Second Cycle
Credits:	5
Module Coordinator:	Horacio Gonzalez-Velez
Module Author:	MICHAEL BRADFORD
Departments:	School of Computing
Specifications of the qualifications and experience required of staff	This module requires a lecturer holding a Master’s degree or higher, in a discipline with a significant programming/mathematics component. e.g. Computer Science, Mathematics, Computational Physics. Lecturer: Mr. Michael Bradford

Learning Outcomes

On successful completion of this module the learner will be able to:

#	Learning Outcome Description
LO1	Interpret and apply mathematical and quantum mechanical principles to qubit systems.
LO2	Critically assess the similarities and differences between quantum and classical computation.
LO3	Analyse computational problems and formulate solutions through the implementation of algorithms for quantum computers.

Dependencies

Module Recommendations

No recommendations listed

Co-requisite Modules

No Co-requisite modules listed

Entry requirements	A cognate level 8 degree.

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Module Content & Assessment

Indicative Content
Introduction Results from the theory of quantum mechanics. Spin and polarization. Measurements/Observables. Randomness and probability. Bits and Qubits. Quantum parallelism and interference.
Linear Vector Spaces and Hilbert Spaces Review of linear spaces.. Hilbert spaces. Dirac notation. Operations and operators.
Matrix Representations The Bloch Sphere. Pauli Matrices. Orthogonal and unitary matrices. Operations and operators. Eigenvectors and eigenvalues.
Quantum Circuits Logic Gates. Reversibility. Multi-qubit Gates. Diagrammatic representation. Deutsch's Algorithm.
Programming for Quantum Computing Programming environments. Language support. Simulation. Quantum Computing cloud services.
Entanglement Entangled states. Bell's Inequalities. Using the CNOT gate. No Cloning Theorem. Quantum Teleportation.
Applications Quantum Cryptography. Quantum Key Distribution. Ekert Protocol. BB48 Protocol. Dense coding.
Quantum Fourier Transform Fourier Series. Discrete Fourier Transform. Quantum Fourier Transform.
Quantum Algorithms Deutsch-Josza Algorithm. Simon's Algorithm.
Quantum Algorithms Grover's Search Algorithm.
Quantum Algorithms Schor's Algorithm.
Ramifications of Quantum Computing Quantum Hardware. Quantum Supremacy. Data Security.

Assessment Breakdown	%
Coursework	40.00%
End of Module Assessment	60.00%

Assessments

Full Time

Coursework

Assessment Type:	Continuous Assessment	**% of total:**	40
Assessment Date:	Week 8	**Outcome addressed:**	1,3
Non-Marked:	No		

Assessment Description:
Design and implement a QC circuit to model and solve problems.

Assessment Type:	Formative Assessment	**% of total:**	Non-Marked
Assessment Date:	n/a	**Outcome addressed:**	1,2,3
Non-Marked:	Yes		

Assessment Description:
Formative assessment will be undertaken utilising exercises and short answer questions during certain tutorials. In class discussions will be undertaken on contemporary topics. Feedback will be provided individually or as a group in oral format.

End of Module Assessment

Assessment Type:	Terminal Exam	**% of total:**	60
Assessment Date:	End-of-Semester	**Outcome addressed:**	1,2,3
Non-Marked:	No		

Assessment Description:
n/a

No Workplace Assessment

Reassessment Requirement

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
Learners who fail this module will be required to sit a repeat examination where all learning outcomes will be examined.

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Module Workload

Module Target Workload Hours 0 Hours

Workload: Full Time

Workload Type	*Workload Description*	*Hours*	*Frequency*	*Average Weekly Learner Workload*
Lecture	Classroom & Demonstrations (hours)	24	Every Week	24.00
Tutorial	Other hours (Practical/Tutorial)	24	Every Week	24.00
Independent Learning	Independent learning (hours)	77	Every Week	77.00
			Total Weekly Contact Hours	48.00

Module Resources

Recommended Book Resources
Michael A. Nielsen,Isaac L. Chuang. (2010), Quantum Computation and Quantum Information, Cambridge University Press, p.702, [ISBN: 9781107002173].
Bernard Zygelman. (2018), A First Introduction to Quantum Computing and Information, Springer, p.233, [ISBN: 3319916289].
N. David Mermin. (2007), Quantum Computer Science, Cambridge University Press, p.233, [ISBN: 0521876583].
Supplementary Book Resources
Chris Bernhardt. (2019), Quantum Computing for Everyone, MIT Press, p.216, [ISBN: 0262039257].
This module does not have any article/paper resources
This module does not have any other resources

Discussion Note:	