Syllabus Attività Formativa

Anno Offerta	2023
Corso di Studio	B33 - DATA SCIENCE
Regolamento Didattico	B33-22-22
Percorso di Studio	GEN - GENERICO
Insegnamento/Modulo	A423703 - QUANTUM COMPUTING -
Attività Formativa Integrata	-
Partizione Studenti	-
Periodo Didattico	S1 - Primo Semestre
Sede	
Anno Corso	2
Settore	FIS/02 - FISICA TEORICA, MODELLI E METODI MATEMATICI
Tipo attività Formativa	C - Affine/Integrativa
Ambito	70318 - Attività formative affini o integrative
CFU	6.0
Ore Attività Frontali	48.0
AF_ID	178668

Tipo Testo	Codice Tipo Testo	Num. Max. Caratteri	Obbl.	Testo in Italiano	Testo in Inglese

Lingua insegnamento	LINGUA_INS	100	Sì		English
Contenuti	CONTENUTI	2000	Sì		1) The postulates of quantum mechanics; 2) Quantum phenomena; 3) The Quantum bits, elementary units of quantum computing; 4) Algorithms and protocols; 5) Quantum Error correction; 6) Quantum Computers: State of the art; 7) Quantum Algorithms for NISQ devices.
Testi di riferimento	TESTI_RIF		Sì		-M. A. Nielsen and I. L. Chuang. Quantum Computation and Quantum Information. - QUANTUM COMPUTING: A Gentle Introduction, Eleanor Rieffel and Wolfgang Polak -Other documents provided during the course.
Obiettivi formativi	OBIETT_FORM	3000	Sì		At the end of the course the student must: 1. master the mathematical tools used in quantum computation; 2. know the main quantum logic gates; 3. be able to describe a quantum algorithm through a quantum circuit; 4. know the main physical systems used to implement quantum computation; 5. better understand concepts such as

					quantum superposition and entanglement; 6. know and formally describe the main sources of error that can occur during quantum computation; 8. apply the basic techniques of quantum error correction; 9. be able to read and understand a research article on quantum computing. 10. understand how to use the QPU's available on the market to solve real problems.
Prerequisiti	PREREQ	2000	Sì		Basic knowledge of physics and computer science
Metodi didattici	METODI_DID	2000	Sì		The course is structured in 40 hours of frontal lectures and 8 hours for classroom exercises. It is highly recommended to attend the classes, but not compulsory, and interact with the teacher. The course includes classes using the blackboard. Educational material will also be provided for further study after the classes.
Altre informazioni	ALTRO	2000	Sì		
Modalità di verifica	MOD_VER_APPR	3000	Sì		The exam consists of an oral exam lasting about one hour in which the student answers specific questions on quantum computing

dell'apprendimento					and proves to have acquired familiarity with the topics covered in the course.
Programma esteso	PROGR_EST		Sì		1) The postulates of quantum mechanics: State spaces, evolution, quantum measurement. The density operator, ensembles of quantum states, the Schmidt decomposition and purification; 2) Quantum phenomena: Superposition, entanglement, the EPR paradox and the Bell's theoorem; 3) The Quantum bits, elementary units of quantum computing: Quantum bits and Bloch sphere, single-qubit operations, multi qubits operations and tensor product, controlled operations, measurement, universal quantum gates. 4) Algorithms and protocols: Circuits, quantum speed-up, teleportation, quantum parallelism. Basic algorithms: Deutsch-Josza, Grove, Shor, Quantum Fourier transform, Quantum phase estimation. 5) Quantum Error correction: Examples of quantum error correcting codes: correction of Single Bit-Flip errors, correction of single phase-flip errors, correction of all Single-Qubit. 6) Quantum computers: state of the art: Physical realization of a quantum computer.

					The IBMQ and PASQAL devices. Introduction to quantum annealing and the D-wave quantum computer. 7) Quantum Algorhitms for NISQ devices: Variational Quantum Eigensolver (VQE), Quantum Approximate Optimization Algorithm (QAOA), Quantum Neural Networks (QNN).