# Quantum Computation and Quantum Information

A joint course for the PhD in “Mathematics and Models” (DISIM) and “Physics and Chemistry” (DSFC) – Università degli Studi dell’Aquila.

Target: PhD students in:
- Mathematics (missing knowledge in Quantum Mechanics, Information Theory and Computer Science).
- Physics (missing knowledge on Computer Science and Information Theory).
- Chemistry (missing knowledge on Hilbert Space algebra, Computer Science and Information Theory).


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<thead>
<tr>
<th>Days</th>
<th>Topics</th>
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<th>Teacher</th>
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</table>
| 20 nov 11.30-13.30 Aula 1.5 | Introduction to Quantum Mechanics and Qubits | - Linear vector spaces  
- The postulates of QM  
- Qubit and its formalism  
- The density matrix  
- Generalized measurement  
- Quantum channels | NC chapters 1.2 + 1.5  
2.1-2.4  
11.3-11.33 | Simone Paganelli (Univaq) |
| 21 nov 11.30-13.30 Aula C 1.16 |  |  |  |  |
| 22 nov 14.30-16.30 Aula 1.6 |  |  |  |  |
| 27 nov 11-13 Aula 1.5 | Introduction to Quantum Information | - Pure state entanglement  
- Majorization criterion  
- Local operations and classical communication  
- Entanglement distillation and dilution for pure states  
- Mixed state entanglement  
- Entanglement measurements  
- Turing machines: deterministic, non-deterministic, probabilistic and quantum.  
- Computational classes (P, NP, BPP, BQP) and proprieties. | NC chapters 2.5  
3.1-3.3  
12.5 | Ugo Marzolino  
(R. Boskovic Institute, Zagreb) |
| 29 nov 14.30-16.30 Aula 1.6 |  |  |  |  |
| 6 dec 14.30-16.30 Aula 1.6 | Quantum Circuits and Algorithms | Single and double qubit gates with examples.  
Analytical solution of a simple Hamiltonian that will be solved in the tutorial. Simple algorithms | NC chapters 1.3,1.4 + online material on IBM-Q websites | Leonardo Guidoni  
(Univaq) |
| Lab. of Comp. Physics  
11 dec 11.30-13.30  
11 dec 14.30-16.30  
12 dec 11.30-13.30 | Hands on Tutorial on the IBM-Q and Quantum Experience | General overview on perspective of quantum computation and practical Implementation of algorithms on the IBM-Q quantum computer and simulator (python-based). | Online material on IBM-Q website + qiskit tutorial | Federico Mattei  
(IBM-Italia) |