School of Mathematics **Spring 2017**

QUANTUM COMPUTATION

Guide to examinable material

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As a general rule, content covered in lectures is all examinable, whereas content not covered in lectures and deferred to the lecture notes (e.g. additional proofs or remarks) is not examinable in itself. However, this content may provide useful background reading.

When an algorithm is listed below, you are not expected to remember all technical details in the definition of the algorithm or its proof of correctness. However, you are expected to be able to understand and be able to reproduce the key points in the proof; give a high-level description of the algorithm; perform calculations relating to the algorithm; and explain its key ideas.

If in doubt, please ask.

The following content is **examinable**:

1. **The quantum circuit model.**
   - Basic linear algebra (matrices, vectors, unitarity, eigenvalues, eigenvectors, etc.).
   - Dirac (bra-ket) notation.
   - The quantum circuit formalism (its meaning, standard gates, writing a circuit as a unitary operator, manipulating circuits, writing an algorithm as a circuit).
   - Implementation of classical logic gates as quantum gates.
   - Query complexity model and oracle operators.
2. **Quantum algorithms.**
   - The Deutsch-Jozsa algorithm.
   - Grover's algorithm (for a unique marked element and for multiple marked elements). The amplitude amplification algorithm is not examinable.
   - The quantum Fourier transform (definition, efficient implementation as a quantum circuit).
   - The periodicity-determination algorithm.
   - Shor's algorithm (overall factorisation algorithm, applying the QFT to determine an approximate period, using continued fractions to extract the period). Proofs of number-theoretic ingredients and proof of lower bound on probability of obtaining a good outcome are not examinable.

- Phase estimation algorithm and application to quantum counting. Proof of Theorem 6.1 is not examinable.
- Hamiltonian simulation algorithm.

3. **Noise and quantum channels.**

   - The concept of quantum channels and Kraus representations; criteria that a quantum channel must satisfy.
   - Qubit quantum channels as maps on the Bloch sphere.
   - Concept of quantum error-correction and Shor's 9 qubit code.
   - The stabilizer formalism. Calculation of the dimensionality of a stabilizer subspace is not examinable.

The material covered in the guest lecture on experimental quantum computing is not examinable.