
Quantum Information
Sheet 5

2020

Hints: 01/04/2020

Hand-in: 08/04/2020

Solutions: 15/04/2020

There will be no penalty for late hand-in, but handing in on-time will allow the TAs to address your problems.

1. Single Qubit Clifford Gates

If a gate U is a Clifford gate, the following property holds

$$UPU^\dagger \sim \pm P'.$$

Here both P and P' are Pauli operators, and the \sim denotes equality up to a factor of ± 1 or $\pm i$

- (a) Show that the Pauli operators themselves are Clifford gates.
- (b) Show that H , S and S^\dagger are Clifford gates.
- (c) Show that $T = S^{1/2}$ is not a Clifford gate.

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2. Two Qubit Clifford Gates

For more than one qubit, Clifford gates map between tensor products of Pauli operators. For two qubits

$$U(P \otimes Q)U^\dagger \sim \pm (P' \otimes Q').$$

Here P , P' , Q and Q' are all Pauli operators.

- (a) Show that the controlled-NOT is a Clifford gate.
- (b) Show that the controlled-Hadamard is not a Clifford gate.

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