Problem set 3: Quantum circuits
Due 5 October 2007

1) Is the SWAP gate universal when combined with arbitrary single-qubit rotations? Argue why/why not. For your reference:

$$U_{swap} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

2) In the teleportation protocol discussed in class, the entangled state that we had available at the start was the state $(|00\rangle + |11\rangle)/\sqrt{2}$. If the initial entangled state were instead the state $(|00\rangle - |11\rangle)/\sqrt{2}$, could you still teleport a qubit state? If not, prove. If yes, show how.

3) Study what Deutsch's algorithm does, and how it works (see e.g. Nielsen and Chuang 1.4.3). Discuss how quantum parallellism enters. Discuss the role of entanglement in this algorithm. What do you conclude from your finding about entanglement?