# Exam Question for D0b

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April 8, 2002

1.

2. *Answer part (a) and either part (b) or part (c).*

    a.   i. Define the *Hamiltonian Circuit Problem* (HCP).

                                                                                              [3 marks]

        ii. Define the *Travelling Salesman Problem* (TCP) and the *Travelling Salesman Decision Problem* (TSDP).

                                                                                           [4 marks]

       iii. Let $A$ be an algorithm that solves TSDP. Design an algorithm $B$ that uses $A$ to obtain a reasonably efficient solution to TSP.

                                                                                           [5 marks]

                                                             [Total for part (a): 12 marks]

    b.   i. What is an **NP**-*hard* problem?

                                                                                          [4 marks]

        ii. Find a $p$-time reduction of HCP to TSDP.

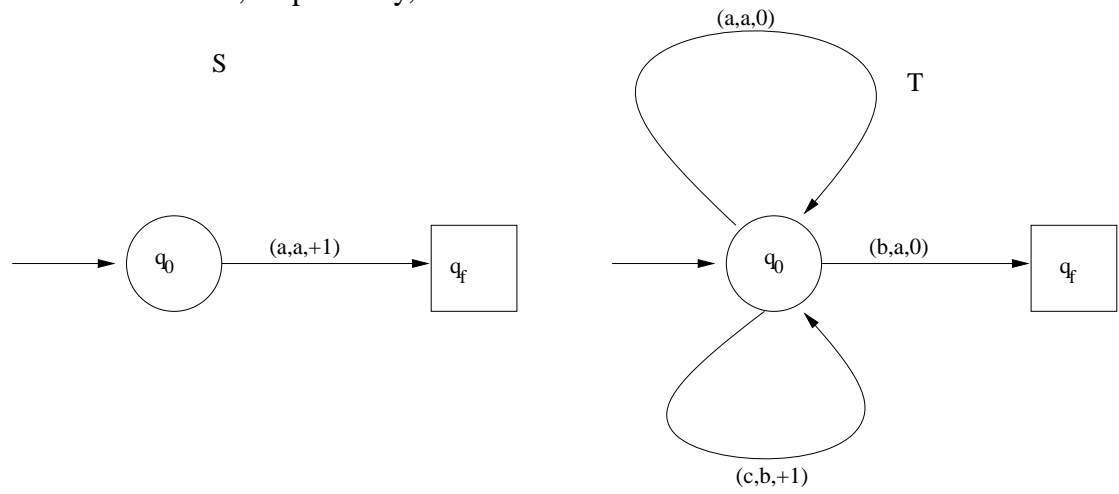                                                                                          [4 marks]

       iii. Assuming that HCP is **NP**-hard, prove that TSDP is **NP**-hard too.

                                                                                   [5 marks]

                                                                   [Total for part (b): 13 marks]

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c. i. What is the *Halting Problem*?

Below are state-transition diagrams of Turing machines $S$ and $T$. $q_0$ and $q_f$ denote the start and halt state, respectively, for each machine.

S

T

(a,a,0)

$q_0$    (a,a,+1)    $q_f$

$q_0$    (b,a,0)    $q_f$

(c,b,+1)

ii. Which of the following are yes-instances of the Halting Problem and which are no-instances?

1. $S$ with input string "*bbaba*"

2. $T$ with input string "*abcba*"

3. $T$ with input string "*ccbaa*"

4. $T$ with input string "*cccabc*".

iii. Prove that the Halting Problem is undecidable.

[Total for part (c): 13 marks]

END OF PAPER