Illinois Institute of Technology
Department of Computer Science

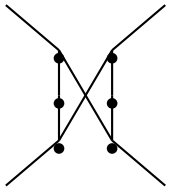
Homework Assignment 12

CS 535 Design and Analysis of Algorithms
Fall Semester, 2016

Due: Thursday, November 17, 2016

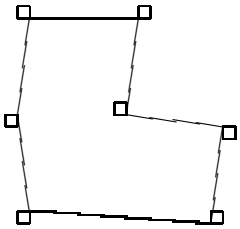
Remember the Honesty Pledge!

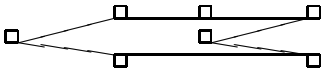
1. Explain why the widget in Figure 34.16 (page 1092 of CLRS3) cannot be replaced with the simpler graph



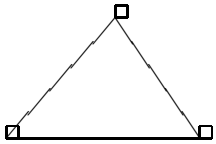
2. On the course web site you will find a paper entitled "On the NP-Completeness of Cryptarithms." Read the paper and give the cryptarithm puzzle that the reduction from 3-CNF-SAT gives for the 3-CNF boolean expression on line 15 of page 1082 in CLRS3. What is the base of the puzzle?

3. You are given a chain of n rigid struts of lengths $l_1, l_2, l_3, \ldots, l_n$ linked together into a cycle by n hinges. The CHAIN-FOLDING problem is to determine if a given chain can be laid out flat on a single line. We assume that hinges and struts are infinitesimally thin. For example, the following chain can be so positioned:





whereas the following chain cannot:



(a) Prove CHAIN-FOLDING is in NP.

(b) Prove CHAIN-FOLDING is NP-hard by reduction from PARTITION, which you may assume to be NP-complete:

PARTITION($\{x_1, x_2, \ldots x_n\}$) is true if and only if there exists $a_i \in \{-1, +1\}$ such that

$$\sum_{i=0}^{n} a_i x_i = 0.$$

(c) Prove PARTITION is NP-hard using the following reduction to SUBSET-SUM (CLRS3, page 1097):

$$f(\langle S, t\rangle) = \begin{cases} \{1, 2\} & \text{if } t > \alpha \\ \{1, 2, 3\} & \text{if } t = 0, \alpha \\ S & \text{if } t = \alpha/2 \\ S \cup \{\alpha + t, 2\alpha - t\} & \text{otherwise} \end{cases}$$

where

$$\alpha = \sum_{x \in S} x.$$

4. **PhD Qualifying Exam Section Problem 12.** You are given a directed graph $G = (V, E)$ with weights w_e on its edges $e \in E$. The weights can be negative or positive. The ZERO-WEIGHT-CYCLE problem is to decide if there is a non-empty simple cycle in G so that the sum of edge weights on this cycle is exactly 0. Prove that ZERO-WEIGHT-CYCLE is NP-complete. You may only use problems proved NP-hard in class or in the text for your reduction.