

## HOMEWORK 5

1. Consider the following table, which presents the approximate flight time (in minutes including connections) between each pair of cities:

	Istanbul	Ankara	Erzurum	Adana	Izmir
Istanbul	-	55	105	80	60
Ankara	60	-	75	60	75
Erzurum	110	90	-	195	135
Adana	80	60	175	-	85
Izmir	60	75	120	80	-

Note that travel times may not be symmetric due to the rotation of the earth and different congestion levels in the airports. Suppose that you live in Istanbul. You need to visit each city exactly once and return to Istanbul. Your goal is to minimize the total flight time.

- (a) What is the best 1-Tree lower bound for the given problem.
  - (b) What is the best Held-Karp lower bound for the given problem.
  - (c) Suggest and implement a heuristic method to find a feasible tour for the given problem. What is the optimality gap your algorithm achieves?
2. Consider the three network instances (Networks A, B and C) given in the attached TSPdata.xlsx file.
    - (a) Assume Euclidean distances between the nodes and find the shortest TSP tours for each network instances. How many cuts (subtour elimination constraints) added to find optimal solution?
    - (b) For each problem instance find the best 1-Tree lower bound for each problem instance.