**Problem 1 [Travelling salesman]**

There are 6 cities with distances between them given by the table below:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 |
| 1 |  | 11 | 7 | 6 | 8 | 14 |
| 2 |  |  | 7 | 9 | 12 | 13 |
| 3 |  |  |  | 3 | 7 | 8 |
| 4 |  |  |  |  | 4 | 8 |
| 5 |  |  |  |  |  | 10 |
| 6 |  |  |  |  |  |  |

Formulate and solve the TSP problem (going from city 1 to city 6 and then back to city 1, visiting each city once (except for city 1), no cycles allowed) using Excel Solver.

**Problem 2 [The route of your e-mail]**

A packet‐switched network is a digital communications network that groups all transmitted data, irrespective of content, type, or structure into suitably‐sized blocks, called *packets*. The network over which packets are transmitted is a shared network which routes each packet independently from all others and allocates transmission resources as needed.

Imagine that you are presented with a plan of a packet-switched network (presented in the picture below), where there are two classes of data being sent through the network (class x should start from origin node x to the destination node x, where x belongs to {1,2}). Each connection has a maximal flow capacity (indicated on the picture) and can be shared by both classes of packets. If this flow capacity ever gets exceeded, a randomly chosen packet which is directed through this connection is dropped altogether and lost to ensure smooth functioning of the network (it must be send again). The goal is to design a plan of transmitting packets through the network so that the overall flow is maximized.



1. Formulate a network flow program.
2. Solve it in Excel
3. Suppose now that the information transmitted from source 1 to destination 1 has 4 times greater priority than the information transmitted from source 2 to destination 2. Modify the goal function and solve it again.
4. Assume that the changes introduced in point C. above hold. There are some other modifications in the network: A connection (3,7), (8,10), and (9,13) ceased to exist. Instead, new connections were created: (3,8) and (8,13) with maximum flow capacity equal to 4 and 2, respectively. The maximum flow of the existing connections (8,11) and (10,13) was raised to 2 and 4, respectively. Solve the modified problem.

**Problem 3 (Empty mileage)**

A transportation company has a number of identical trucks, which carry commodities between 7 cities. A transportation plan is given in the table below (numbers in the left table denote trucks needed to carry goods between any pair of cities) along with the distance between any two cities (the table on the right).

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| pij | 1 | 2 | 3 | 4 | 5 | 6 | 7 |  | dij | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | 0 | 5 | 8 | 11 | 4 | 6 | 16 |  | 1 | 0 | 18 | 34 | 55 | 10 | 21 | 50 |
| 2 | 10 | 0 | 8 | 7 | 6 | 5 | 12 |  | 2 |  | 0 | 53 | 29 | 64 | 19 | 10 |
| 3 | 9 | 4 | 0 | 5 | 5 | 10 | 7 |  | 3 |  |  | 0 | 18 | 33 | 22 | 14 |
| 4 | 4 | 3 | 3 | 0 | 6 | 9 | 17 |  | 4 |  |  |  | 0 | 54 | 9 | 36 |
| 5 | 20 | 15 | 4 | 9 | 0 | 8 | 6 |  | 5 |  |  |  |  | 0 | 13 | 15 |
| 6 | 10 | 9 | 7 | 8 | 11 | 0 | 11 |  | 6 |  |  |  |  |  | 0 | 19 |
| 7 | 8 | 7 | 6 | 5 | 7 | 9 | 0 |  | 7 |  |  |  |  |  |  | 0 |

1. Find an optimal plan for empty trucks, so that the mileage of empty trucks will be minimal.