Lab 1: Brute-force algorithms

Q1. Find the contiguous subarray of largest sum.

Problem statement: Given an array of n integers, $\{a_1, a_2, .., a_n\}$. Apply the Brute-force approach to find the subsequence $\{a_i, a_{i+1}, .., a_{j-1}, a_j\}$ such that $\sum_{k=i}^{j} a_k$ is largest, where $1 \le i \le k \le j \le n$. If all integers in the sequence are negative, the subsequence is empty and the result is 0.

Input: Read the input data from a text file whose format is as follows

- 1st line: a positive integer n to indicate the size of the input array
- 2nd line: n integers, two consecutive numbers are separated by a single space " "

Output: Print the output data to the console as follows

- The subsequence with the largest sum of elements
- The sum of the above subsequence

Example of input and output:

Input text file	Output to console
8 -2 -3 4 -1 -2 1 5 -3	4 -1 -2 1 5 7

Other requirements: You must implement all the three algorithms shown in the lecture and present all the results to the console once.

Q2. The change-making problem.

Problem statement: Given k denominations: $d_1 < d_2 < .. < d_k$ where $d_1 = 1$. Apply the Brute-force approach to find the minimum number of coins (of certain denominations) that add up to a given amount of money n.

Input: Read the input data from a text file whose format is as follows

- 1st line: a positive integer k to indicate the number of denominations
- 2nd line: k positive integers describing k denominations, sorted descending, two consecutive numbers are separated by a single space " ". The last value must be one.
- 3rd line: a positive integer n to indicate the amount of money required exchange

Output: If there exists a solution, print the amount of each denomination to the console. Otherwise, output the string "No solution".

Example of input and output:

Input text file	Output to console
4 25 10 5 1 72	25: 2 10: 2 5: 0 1: 2

Q3. The convex-hull problem.

Problem statement: Given a set of n two-dimensional points. Apply the Brute-force approach to find the convex-hull of these points, i.e., the smallest convex polygon that contains all the points either inside or on its boundary.

Input: Read the input data from a text file whose format is as follows

- 1st line: a positive integer n to indicate the number points
- n next lines: Each line represents the two-dimensional coordinate of a point, in which the two coordinate values are separated by single space " ".

Output: Print to the console the set of points belonging to the convex-hull, each point is on a line.

Example of input and output:

Input text file	Output to console
7 0 0 1 1 3 3 1 3 0 4 4 0 4 4	0 0 4 0 4 4 0 4

Other requirements: You must use the algorithm given in the lecture.

Q4. The traveling salesman problem.

Problem statement: Given a set of n cities, some pairs of adjacent cities are connected with given distances. Apply the Brute-force approach to find the shortest tour through n cities such that we visit each city exactly once before returning to the city where we started.

Input: Read the input data from a text file whose format is as follows

- 1st line: a positive integer n to indicate the number of cities. The cities are indexed from 1 to n.
- Each of the next lines shows a pair of cities and their distance, $\langle point1\ point\ 2\ distance \rangle$, two consecutive numbers are separated by single space " ".
- The last line shows the number -1, indicating the end of the file

Output: If there exists a solution, print the below output data to the console. Otherwise, print the string "No solution".

- A sequence of cities forming the tour (in their exact order)
- The length of the tour

Example of input and output:

Input text file	Output to console
5 1 2 4 1 4 8 3 4 2 2 5 1 3 5 1 -1	1 2 5 3 4 16

Q5. The sum of subsets problem.

Problem statement: Given a set of n distinct positive integers, $A = \{a_1, a_2, .., a_n\}$. Apply the Brute-force approach to find all subsets of A that sum to a positive integer k.

Input: Read the input data from a text file whose format is as follows

- 1st line: a positive integer n to indicate the size of the input array
- 2nd line: n integers, two consecutive numbers are separated by a single space " "
- 3rd line: a positive integer k

Output: If there exists a solution, print all the subsets to the console, one per line, and two consecutive numbers in a subset are separated by a single space " ". Otherwise, print the string "No solution".

Example of input and output:

Input text file	Output to console
4 1 2 3 4 7	3 4 1 2 4

Q6. The Knapsack problem.

Problem statement: Given n items of known weights, $\{w_1, w_2, .., w_n\}$, and their corresponding values, $\{v_1, v_2, .., v_n\}$, and a knapsack of capacity C. Apply the Brute-force approach to find the most valuable subset of the items that fit into the knapsack.

Input: Read the input data from a text file whose format is as follows

- 1st line: a positive integer C to indicate the capacity of the knapsack
- 2nd line: a positive integer n to depict the number of items
- Each of n following lines represent the weight w_i and value v_i of the item i, where $i = 1, .., n$. The two values are separated by a single line " ".

Output: If there exists a solution, print the output data to the console as follows. Otherwise, print the string "No solution".

- The list of chosen items, whose sum of weights equals C
- The total value of the chosen items

Example of input and output:

Input text file	Output to console
20 5 10 5 4 2 9 4 6 6 7 1	1 2 4 13

Q7. The assignment problem.

Problem statement: There are n people who need to be assigned to execute n jobs, one person per job. The cost if the i^{th} person is assigned to the j^{th} job is a known quantity $C_{i,j}$ (which is a positive

integer) for each pair $i, j = 1, 2, \dots, n$. Apply the Brute-force approach to find an assignment with the minimum total cost.

Input: Read the input data from a text file whose format is as follows

- 1st line: a positive integer n to indicate the number of people, as well as the number of jobs.
- The matrix of people vs. jobs is represented in the next n lines, one row per line. Each line contains n positive integers, two consecutive numbers are separated by a single space " ".

Output: Print the output data to the console as follows

- The job assignment to the first person, second person, and so on.
- The corresponding minimum total cost.

Example of input and output:

Input text file	Output to console
4 9 2 7 8 6 4 3 7 5 8 1 8 7 6 9 4	2 1 3 4 13

Regulations for completing the lab work

- Each question must be implemented as an independent program in a single C++ file (of format .cpp).
- The program must receive input and return output as specified Submissions with wrong regulation will result in a "0" (zero).
- Plagiarism and Cheating will result in a "0" (zero) for the entire course.
- Contact: Here.