QUESTION 1

Consider the following distance matrix for the 7 city symmetric Travelling Salesman Problem (STSP)

$$M = \begin{pmatrix} 0 & 1.5 & 3 & 13 & 3.5 & 4.5 & 1.5 \\ & 0 & 1.5 & 1.3 & 13 & 13 & 2.3 \\ & & 0 & 1.5 & 3 & 13 & 3 \\ & & & 0 & 1.5 & 13 & 20 \\ & & & & 0 & 1.5 & 3.3 \\ & & & & & 0 & 1.5 \\ & & & & & & 0 \end{pmatrix},$$

where $m_{ij} = m_{ji}$. Minimize the above problem using the 2-Opt heuristic. Use $x = (2714653)$ as your starting solution. Count the number of improving solutions during the course of your two optimal procedure and list your improving solutions $(x^i, f(x^i))$. Report also the final solution (route) x^* and the corresponding optimal distance $f(x^*)$.

Total Marks: 10

QUESTION 2

The Knapsack Problem (KP) is considered to be a combinatorial optimization problem. A Knapsack model serves as an abstract model with broad spectrum applications such as: Resource allocation problems, Portfolio optimization, Cargo-loading problems and Cutting stock problems. The Quadratic KP (QKP) problem is presented below. QKP has quadratic objective function (it is an extension of the linear Knapsack problem) where there are additional terms in the objective function that describes extra profit (p_{ij}) gained from choosing a particular combination of items. The mathematical model of the problem is defined as follows:

$$\max \sum_{i=1}^{n} v_i x_i + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} p_{ij} x_i x_j \quad \text{such that}$$

$$\sum_{j=1}^{n} w_j x_j \leq W.$$

Consider the above QKP problem with $n = 10$ items and the following data
$v_i = 7, 6, 13, 16, 5, 10, 9, 23, 18, 12$;
$w_i = 13, 14, 14, 15, 15, 9, 26, 24, 13, 11$, $W = 40$ and the symmetic matrix P with elements

$$P = \begin{pmatrix} 0 & 12 & 7 & 6 & 13 & 8 & 11 & 7 & 15 & 23 \\ & 0 & 15 & 13 & 10 & 15 & 9 & 10 & 8 & 17 \\ & & 0 & 11 & 16 & 6 & 8 & 14 & 13 & 4 \\ & & & 0 & 10 & 13 & 14 & 14 & 17 & 15 \\ & & & & 0 & 9 & 7 & 25 & 12 & 6 \\ & & & & & 0 & 2 & 13 & 12 & 16 \\ & & & & & & 0 & 8 & 18 & 4 \\ & & & & & & & 0 & 9 & 16 \\ & & & & & & & & 0 & 15 \\ & & & & & & & & & 0 \end{pmatrix},$$

Solve the above Knapsack Problem (QKP) using binary coded Genetic Algorithm with the following parameters:
Parameters for GA: p_c =1 (crossover probability), $p_\mu = 10^{-3}$ (mutation probability), Population size N=30, children per iteration m=8, maximum iteration=100. Penalty parameter R=200 for the fitness function. In your final solution, clearly indicate the chosen items in in your optimal solution x^* and the corresponding optimal objective value (profit) $\sum_{i=1}^{n} v_i x_i^* + \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} p_{ij} x_i^* x_j^*$ and the total weight used $\sum_{1=1}^{n} w_i x_i^*$. (Note: use the random number seed:=1000).

Total Marks: 10

SUBMIT YOUR ASSIGNMENT BY 5PM, 5th SEPTEMBER, 2025.

END