UNIVERSIDAD AUTÓNOMA DE NUEVO LEÓN
FACULTAD DE INGENIERÍA MECÁNICA Y ELÉCTRICA
TIPO DE EXAMEN Y/O EVALUACIÓN:
MEDIO CURSO (*Midterm Exam*)

MATERIA/UNIDAD DE APRENDIZAJE: Temas Selectos de Optimización
LEARNING UNIT: Selected Topics on Optimización (in English)

SEMESTER: August – December 2025
ACADEMY: Statistics and Operations Research (*Estadística e Investigación de Operaciones*).
INSTRUCTOR: Dr. Roger Z. Ríos Mercado

DIRECTIONS.- Answer the following questions and/or exercises in the answer sheet. Do not write in this sheet

SECTION 1: QUESTIONS (50 POINTS)

Answer and justify your answer.

1. [*UT1: Combinatorial optimization*; 6 pts] Define a combinatorial optimization problem.
2. [*UT1: Combinatorial optimization*; 6 pts] Define and explain what a brute-force enumeration method is for solving a combinatorial optimization problem.
3. [*UT1: Combinatorial optimization*; 6 pts] When do we say that an optimization problem is easy to solve.
4. [*UT2: Heuristics*; 6 pts] Define and explain what a heuristic method is for solving combinatorial optimization problems.
5. [*UT2: Heuristics*; 6 pts] Under what circumstances or when it is preferable to use a heuristic method instead of an exact optimization method for solving a combinatorial optimization problem?
6. [*UT2: Constructive heuristics*; 6 pts] What is a constructive heuristic?
7. [*UT2: Constructive heuristics for the TSP*; 7 pts] Describe in detail the nearest neighbor heuristic for solving the Traveling Salesman Problem. You may illustrate your idea with an example or drawing.
8. [*UT2: Constructive heuristics for the TSP*; 7 pts] Describe in detail the nearest insertion heuristic for solving the Traveling Salesman Problem. You may illustrate your idea with an example or drawing.

SECTION 2: PROBLEMS (50 POINTS)

9. The Set Covering Problem (SCP) is defined as follows. Given a set A of n items $A = \{ a_1, a_2, \ldots, a_n \}$, and given a family or collection of m subsets $S_j \subseteq A$, $j \in J$, $\bigcup_{j \in J} S_j \square A$, with an associated cost c_j for each subset $j \in J$, it is sought to find a subcollection or subfamily X of J, such that the union of all subsets in X "covers" set A, that is, $\left(\bigcup_{j \in X} S_j = A\right)$ so as to minimize the total covering cost, given by $\left(\sum_{j \in X} c_j\right)$. Below, there is an example for a problem instance with: $A = \{ a_1, a_2, \ldots, a_{10}\}$, $J = \{ 1, \ldots, 12\}$.

j	S_j	c_j
1	$\{ a_1, a_3, a_5, a_7 \}$	13
2	$\{ a_2, a_6, a_9, a_{10} \}$	4
3	$\{ a_1, a_2, a_4, a_7, a_9, a_{10} \}$	22
4	$\{ a_2, a_3, a_4, a_8 \}$	6
5	$\{ a_6, a_7, a_8, a_9 \}$	14
6	$\{ a_2, a_5, a_7, a_9, a_{10} \}$	19
7	$\{ a_1, a_2, a_3 \}$	3
8	$\{ a_1, a_5, a_6, a_8, a_9 \}$	16
9	$\{ a_4, a_7, a_8 \}$	17
10	$\{ a_2, a_5, a_6, a_8 \}$	12
11	$\{ a_1, a_9 \}$	5
12	$\{ a_5, a_6, a_7, a_{10} \}$	15

Since it must be decided what subsets of J must be chosen, then a possible feasible solution to SCP can be represented by an m-vector of binary (0,1) coordinates, where the j-th coordinate is equal to 1 if subset J belongs to the solution and equal to 0 otherwise. For instance, solution X = (0,0,1,0,0,1,0,0,1,0,1,1) means that subsets 3, 6, 9, 11, and 12 of J are chosen.

(a) [*UT1: Combinatorial optimization*; 6 pts] Is X^1 = (1,0,0,1,0,0,1,0,0,1,0,0) a feasible solution? Justify your answer.

(b) [*UT1: Combinatorial optimization*; 6 pts] Is X^2 = (0,1,0,0,0,0,1,0,1,0,0,1) a feasible solution? Justify your answer.

(c) [*UT1: Combinatorial optimization*; 8 pts] Sort the following three solutions from best to worst. Justify your answer.
X^3 = (0,1,0,0,0,0,1,0,1,0,0,1),
X^4 = (0,0,1,1,0,0,0,0,0,1,0,0),
X^5 = (0,1,0,1,0,0,1,0,0,0,0,0).

(d) [*UT2: Constructive heuristics*; 20 pts] Design a constructive heuristic for the SCP. Show clearly each step either in pseudocode or flow chart and explain your code when necessary.

(e) [*UT2: Constructive heuristics*;10 pts] Illustrate how your heuristic works, step by step, by applying it to the example above.