UNIVERSITY
OF SKÖVDE

School of Engineering Science

WRITTEN EXAMINATION

Course: Engineering Optimization: Methods and Applications

Sub-course

Course code: VP747A

Credits for written examination: 2 ECTS

Date: 2026-08-25

Examination time: 14:15 – 18:30

Examination responsible: Anna Syberfeldt

Teachers concerned: Masood Fathi

Aid at the exam/appendices: Nothing

Other

Instructions

- ☐ Take a new sheet of paper for each teacher.
- ☒ Take a new sheet of paper when starting a new question.
- ☒ Write only on one side of the paper.
- ☒ Write your name and personal ID No. on all pages you hand in.
- ☒ Use page numbering.
- ☒ Don't use a red pen.
- ☒ Mark answered questions with a cross on the cover sheet.

Grade points (ECTS)

A 40 - 37 B 36 - 33 C 32 - 29 D 28 - 25 E 24 – 21 F 20 - 0

Examination results should be made public within 18 working days

Good luck!

Total number of pages: 3

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Question 1: Dynamic Programming (8p)

A logistics company has 5 delivery vans to allocate among three service zones. Because customer demand and operating conditions differ among the zones, the profit obtained from each zone depends on the number of vans assigned to it.

Each van must be assigned completely to one service zone and cannot be divided between zones. You may also assign zero vans to one or more service zones.

The values in the table below represent the total profit obtained from each service zone when a given number of vans is assigned to it. For example, assigning 2 vans to Service Zone 1 results in a total profit of 9. The values are total profits, not profit per van.

Determine how the 5 vans should be allocated among the three service zones to maximize total profit. *Solve the problem using **Dynamic Programming** with the **backward approach**. Identify the **stage**, **state**, and **decision**, and **show all calculations in tabular form**.*

Service Zone	0 vans	1 van	2 vans	3 vans	4 vans	5 vans
Zone 1	0	5	9	14	18	21
Zone 2	0	6	10	15	19	23
Zone 3	0	4	11	16	20	24

Question 2: Dual programming (5p)

Write the **dual LP** of the following primal LP model.

Maximize $Z = 6x_1 + 8x_2 + 5x_3$

Subject to:
$3x_1 + 2x_2 + x_3 \leq 18$
$x_1 - 2x_2 + 3x_3 \leq 10$
$2x_1 + x_2 - x_3 \geq 4$
$x_1, x_2, x_3 \geq 0$

You can use the following table to help you write the dual model.

Label	Primal Problem (or Dual Problem)	Dual Problem (or Primal Problem)
	Maximize Z (or W)	Minimize W (or Z)
Sensible	Constraint i: ≤ form ←	→ Variable y_i (or x_i): $y_i \geq 0$
Odd	= form ←	→ Unconstrained
Bizarre	≥ form ←	→ $y_i' \leq 0$
Sensible	Variable x_j (or y_j): $x_j \geq 0$ ←	→ Constraint j: ≥ form
Odd	Unconstrained ←	→ = form
Bizarre	$x_j' \leq 0$ ←	→ ≤ form

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Question 3: Branch & Bound (8p)

An electronics manufacturing company produces two products: smart sensors and control units. Both products require processing in two production departments. Department 1 performs component preparation and initial assembly, while Department 2 handles electronic integration and final testing.

The company must determine how many units of each product to manufacture during the next production period in order to maximize total profit. Each smart sensor generates a profit of $75 per unit, while each control unit generates a profit of $50 per unit.

The company has 13 hours of available production capacity in Department 1 and 20 hours in Department 2. Each smart sensor requires 2 hours in Department 1 and 5 hours in Department 2, while each control unit requires 3 hours in Department 1 and 2 hours in Department 2. Since partial products cannot be manufactured, the production quantities must be non-negative integers.

x_1 represents the number of smart sensors produced

x_2 represents the number of control units produced

The problem is formulated as follows:

Maximize $Z = 75x_1 + 50x_2$

Subject to

$2x_1 + 3x_2 \leq 13$

$5x_1 + 2x_2 \leq 20$

$x_1, x_2 \geq 0$ and Integer

Determine the optimal production quantity of each product and the corresponding maximum profit **using the Branch and Bound method. Show all calculations and solution steps**. At each branching stage, clearly identify the branching variable and the corresponding branching constraints.

If more than one decision variable has a fractional value, **branch first on the variable with the larger fractional part**.

Graphically present the complete Branch and Bound tree. For each node, show the LP solution, objective value, branching decision, and node status. State the final optimal integer solution, the value of each decision variable, and the maximum profit.

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Question 4: Simplex Method (A:8p; B:4P)

A) A company manufactures two products, P_1 and P_2, using three machines, A, B, and C. During the coming week, Machine A has 5 hours of available capacity, Machine B has 12 hours, and Machine C has 14 hours. One unit of P_1 requires 1 hour of Machine A and 2 hours of Machine C, while one unit of P_2 requires 2 hours of Machine B and 2 hours of Machine C. Each unit of P_1 generates a profit of \$4, while each unit of P_2 generates a profit of \$5. Determine the optimal production quantities of P_1 and P_2 that maximize the company's total profit using the Simplex method.

Machines	P_1	P_2	Available Capacity
A	1	0	5
B	0	2	12
C	2	2	14
Profit per unit	\$4	\$5	–

The linear programming (LP) model is as follows.

Let x_1 = number of units of P_1 and x_2 = number of units of P_2.

Maximize $Z = 4x_1 + 5x_2$

Subject to:
$x_1 \leq 5$
$2x_2 \leq 12$
$2x_1 + 2x_2 \leq 14$
$x_1, x_2 \geq 0$

Solve the given LP problem using the ***Simplex*** algorithm. *Present all the calculations and solution steps. Follow the* ***tabular solution approach*** *and show all the steps in a table.*

B) Under what conditions would you choose the **Simplex**, **Dual Simplex**, or **Big-M method** to solve a linear programming problem? *Explain and motivate your choice for each method.*

Question 5: Solution methods (A:4P; B:3P)

A) You are faced with an optimization problem. How would you decide whether to use an exact optimization method or a metaheuristic? *Explain and motivate the factors that should influence your decision.*

B) What is a local optimum, and why can it be a problem when solving complex optimization problems?