UNIVERSITY
OF SKÖVDE

School of Engineering Science

WRITTEN EXAMINATION

Course: Applied Operations Research

Sub-course

Course code: PR505G

Credits for written examination: 2 ECTS

Date 2025-11-21

Examination time 08:15 – 12:30

Examination responsible: Amos Ng

Teachers concerned: Ehsan Mahmoodi

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 22 - 24 B 19 - 21 C 16 - 18 D 13 - 15 E 10 – 12 F 0 - 9

Examination results should be made public within 18 working days

Good luck!

Total number of pages: 3

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Question 1. Graphical Method (6p)

A production company operates a factory that manufactures two types of products: **Product X** and **Product Y**. The company aims to determine the optimal number of units to produce for each product to maximize total profit. The profit earned from each unit of Product X is $200, and from each unit of Product Y is $300.

The factory has certain resource constraints:

- There are **60 machine hours** available for production.
- There is a supply of raw materials sufficient to produce up to **50 units** in total.

The production requirements are as follows:

- Machine Time Required:
  - Product X: 1 machine hour per unit.
  - Product Y: 2 machine hours per unit.
- Raw Materials Required:
  - Product X: 1 unit of raw material per unit produced.
  - Product Y: 1 unit of raw material per unit produced.

The problem characteristics are summarized in the table below:

	Product X	Product Y	Total Available
Profit Contribution ($ per unit)	$200	$300	
Machine Time Required (hours/unit)	1	2	60 machine hours
Raw Materials Required (units/unit)	1	1	50 units

Write the LP formulation of the problem to maximize the profit. Solve the problem using the **graphical solution method.** *Present all the calculations and solution steps.*

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Question 2. Branch & Bound (6p)

A bookstore offers two types of subscription packages: Package_1 and Package_2. Each Package_1 includes one fiction book and 5 magazines, while each Package_2 includes 2 fiction books and 2 magazines. The bookstore has a stock of 5 fiction books and 15 magazines available for creating these packages. The profit earned is $11 for each Package_1 and $13 for each Package_2.
The linear programming model of the above problem is as follows:

Variables:
X: Number of Package_1
Y: Number of Package_2

Objective:

$$\text{Maximize } Z=11X+13Y$$

Subject to:

$$1X + 2Y \leq 5$$
$$5X + 2Y \leq 15$$

$$X,Y \geq 0, \text{ and Integer}$$

Determine the optimal number of each package (Package_1 and Package_2) to create in order to maximize profit, using the **Branch & Bound** method. *Present all the calculations and solution steps.*

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Question 3. Simplex Method (6p)

Anna is a florist who runs a small flower shop. She offers two types of flower arrangements: bouquets and flower baskets. Each bouquet is sold for $25, and each flower basket is sold for $15. Creating a bouquet takes 1 hour, while creating a flower basket takes 2 hours. Due to her other commitments, Anna can dedicate a maximum of 12 hours a week to making flower arrangements. Her stock allows her to prepare a maximum of 5 bouquets and 6 flower baskets per week. Due to limited delivery options, Anna can deliver a maximum of 8 arrangements (bouquets or baskets) per week.

Variables:

- X= number of bouquets Anna makes each week
- Y= number of flower baskets Anna makes each week

LP Formulation:

Maximize:

$$Z = 25X + 15Y$$

Subject to:

$X + 2Y \leq 12$	(time constraint)
$X \leq 5$	(bouquet stock limit)
$Y \leq 6$	(flower basket stock limit)
$X + Y \leq 8$	(delivery constraint)
$X, Y \geq 0$	(non-negativity constraint)

Solve the given LP problem using the ***Simplex*** algorithm. *Present all the calculations and solution steps.*

Question 4. Hungarian Method (6P)

A manufacturing company needs to assign four jobs to four machines. Each job requires a unique set of capabilities, and each machine has different efficiency levels. The cost of processing each job on each machine, due to factors like energy consumption, setup time, and wear and tear, is given in the table below. The goal is to minimize the total processing cost by optimally assigning the jobs to the machines.

Utilize the **Hungarian method** to determine the best assignment that minimizes the total cost of job allocation. Provide a step-by-step solution, including all calculations, and provide the minimum cost for this task assignment problem. *Present all the calculations and solution steps.*

	Task 1	**Task 2**	**Task 3**	**Task 4**
Job 1	82	83	69	92
Job 2	77	37	49	92
Job 3	11	69	5	86
Job 4	8	9	98	23