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 2023-11-16

Examination time 08:15 – 12:30

Examination responsible: Amos Ng

Teachers concerned: Masood Fathi

Aid at the exam/appendices: Calculator

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)

Consider a hospital that provides two types of services: General Consultations (GC) and Specialized Treatments (ST). Both services require two types of resources: Doctors' time and Nurses' time. The available hours for Doctors and Nurses are limited to 750 hours and 1000 hours, respectively.
The hospital has a contract to provide at least 100 hours of Specialized Treatments and must not provide more than 420 hours of General Consultations due to resource limitations.
The revenue contribution of each service and the time needed from Doctors and Nurses are reported in the table below. The goal is to find the optimal service mix to maximize the revenue.

	General Consultation	Specialized Treatment	Hours available
Profit	40$	50$	----
Doctor Time	1 hrs	1.5 hrs	750
Nurse Time	2 hrs	1 hr	1000

The Linear Programming (LP) formulation of this problem would be:

x_1 = number of General Consultations
x_2 = number of Specialized Treatments

Maximize: $Z = 40x_1 + 50x_2$

Subject to:

$x_1 + 1.5x_2 \leq 750$
$2x_1 + x_2 \leq 1000$
$x_1 \leq 420$
$x_2 \geq 100$
$x_1, x_2 \geq 0$

Solve the problem using the **graphical solution method.** *Present all the calculations and solution steps.*

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Question 2. Branch & Bound (6p)

Let's consider a small electronics manufacturing company, ”Tech Innovators”, that specializes in producing two types of products: Smartphones (x1) and Tablets (x2). The production of these devices requires two types of components: Microchips and Batteries. Manufacturing a Smartphone requires 6 Microchips and 1 unit of Battery. Manufacturing a Tablet requires 4 Microchips and 2 units of Battery.
Currently, ”Tech Innovators” has a limited supply of components for the upcoming production cycle. Microchips: 24 units available, Batteries: 10 units available.
Each Smartphone sold generates a profit of $7,000, and each Tablet sold generates a profit of $5,000.
The challenge for ”Tech Innovators” is to determine the optimal number of Smartphones and Tablets they should aim to produce in the upcoming cycle to maximize their profit, while ensuring they do not exceed the available components. The production quantities for both Smartphones and Tablets must be integer numbers, as it is not feasible to produce fractional units of a device.
The Linear Programming (LP) formulation of this problem would be:

Maximize $Z = 7000\, x_1 + 5000\, x_2$

subject to:
$6\, x_1 + 4\, x_2 \leq 24$
$x_1 + 2\, x_2 \leq 10$
$x_1, x_2 \geq 0$ & Integer

Find the optimal amount of production for each product to maximize the profit using the ***Branch & Bound*** *method. Present all the calculations and solution steps.*

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Question 3. Simplex Method (6p)

John is a baker who runs an online bakery. He sells two types of products: bread and pastries. Each loaf of bread is sold for $30, and each pastry is sold for $10. Baking a loaf of bread takes 2 hours, while baking a pastry takes 1 hour. John can dedicate a maximum of 20 hours a week to baking due to his other commitments. His oven capacity allows him to bake a maximum of 7 loaves of bread and 15 pastries per week. Furthermore, due to delivery constraints, John can only deliver a maximum of 20 items (bread or pastries) per week.
Given these constraints, we want to help John maximize his weekly revenue from selling bread and pastries.

x_1 = number of loaves of bread John bakes each week
x_2 = number of pastries John bakes each week

The Linear Programming (LP) formulation of this problem would be:

Maximize: $Z = 30x_1 + 10x_2$

Subject to:

$2x_1 + x_2 \leq 20$
$x_1 \leq 7$
$x_2 \leq 15$
$x_1 + x_2 \leq 20$
$x_1, x_2 \geq 0$

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

Question 4. Hungarian Method (6P)

A retail company needs to distribute tasks to its sales agents. The company has four against and there are four tasks to be completed. Each task requires a different set of skills, and each sales agent possesses a unique skill set. The cost of preforming each task by each sales agent is summarized in the table below.
Utilize the ***Hungarian method*** to determine the best assignment that minimizes the total cost of task allocation within the company. 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.*

Worker	Task			
	1	2	3	4
1	76	78	70	62
2	74	80	66	62
3	72	76	68	58
4	78	80	66	60