ISE 4623/5023: Deterministic Systems Models / Systems Optimization

University of Oklahoma

School of Industrial and Systems Engineering
Fall 2021

Final Exam (100 points – undergraduate students; 120 points –graduate students)

To solve this Exam, you can use your notes, the book, and any material uploaded in Canvas. You may not look online (outside Canvas) for codes or any help of any kind. Also, you cannot receive assistance of any type from anyone else.

You need to write your name and sign on each page. You need to upload a copy of the document with the solutions in Canvas (PDF format) along with the Gurobi/Excel files used to solve the exam and any other relevant support files. Problems without a proper support will not receive any points. If you are solving the exam with Excel, I suggest using only a single Excel file for the entire exam (using one sheet per problem).

Last name: _____

First name: _____

Student ID: _____

Section (mark with X): _____ ISE 4623

_____ ISE 5023

Pledge: "On my honor, I have neither given nor received inappropriate assistance in the completion of this Exam."

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Problem 1 (40 points): Knapsack problem

Imagine that you are planning your next vacations. For your trip, first you want to determine which items to pack. To take this decision, you make a list of 30 items from which you want to pick the ones to be packed. For each of these 30 items, you know its weight (in pounds) and its associated intrinsic value (the more you want to take the item, the higher its "value"), as indicated below (Table 1).

Table 1. Weight and value of each item

ITEM	Weight (pounds)	Value
Item 1	4	3
Item 2	5	2
Item 3	5	5
Item 4	9	4
Item 5	9	4
Item 6	4	4
Item 7	7	4
Item 8	7	9
Item 9	6	7
Item 10	3	9
Item 11	7	8
Item 12	8	9
Item 13	3	8
Item 14	8	3
Item 15	4	6
Item 16	3	5
Item 17	7	7
Item 18	9	8
Item 19	6	2
Item 20	7	2
Item 21	6	7
Item 22	8	2
Item 23	7	5
Item 24	9	3
Item 25	3	7
Item 26	4	4
Item 27	5	7
Item 28	4	10
Item 29	3	4
Item 30	8	6

PART I. (20 points)

Assume that for your trip you can only use a single bag, with a maximum capacity of 15 pounds. Considering this weight constraint, calculate the optimal packing strategy (the one that maximizes the total value of the items packed)

1.1. (2 points) In the optimal solution, is item 8 packed?
- A. Yes
- B. No

1.2. (2 points) In the optimal solution, is item 10 packed?
- A. Yes
- B. No

1.3. (2 points) In the optimal solution, is item 13 packed?
- A. Yes
- B. No

1.4. (2 points) In the optimal solution, is item 18 packed?
- A. Yes
- B. No

1.5. (2 points) In the optimal solution, is item 27 packed?
- A. Yes
- B. No

1.6. (5 points) In the optimal packing strategy (the one that maximizes the total value packed) what is the total value associated with the items that you can pack in your bag?
- A. 95
- B. 98
- C. 34
- D. 15
- E. 42
- F. 79

1.7. (5 points) In the optimal packing strategy (the one that maximizes the total value packed) what is the total weight associated with the items that you can pack in your bag?
- A. 10
- B. 11
- C. 12
- D. 13
- E. 14
- F. 15

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PART II. (20 points)

Now, assume that for your trip you can use two bags. The first bag has a maximum capacity of 15 pounds and the second one has a maximum capacity of 50 pounds.

1.8. (2 points) In the new optimal solution, is item 8 packed?
A. Yes
B. No

1.9. (2 points) In the new optimal solution, is item 10 packed?
A. Yes
B. No

1.10. (2 points) In the new optimal solution, is item 13 packed?
A. Yes
B. No

1.11. (2 points) In the new optimal solution, is item 18 packed?
A. Yes
B. No

1.12. (2 points) In the new optimal solution, is item 27 packed?
A. Yes
B. No

1.13. (5 points) In the optimal packing strategy (the one that maximizes the total value packed) what is the total value associated with the items that you can pack in your bag?
A. 95
B. 98
C. 34
D. 15
E. 42
F. 79

1.14. (5 points) In the optimal packing strategy (the one that maximizes the total weight associated with the items that you can pack in the first bag?
A. 10
B. 11
C. 12
D. 13
E. 14
F. 15

Problem 2. (40 points) (additional 20 points for Graduate Students or extra credit for undergraduate): TSP

You are still planning your next vacations. For your vacations, you have decided to visit six cities (labeled as city 1, 2, …, 6). Your trip will start and finish in your hometown (labeled as city 7). To visit each of the cities, you can either take a bus or a plane. The travel costs (in USD) and times (in hours) are shown in the tables below (Tables 2 and 3). Note that, as expected, the bus is often much cheaper, but usually takes longer. Also, not that these costs and travel times are not symmetric.

Table 2. Travel times and travel costs for bus trips

Travel time - bus (hours)

		Destination city						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Departure city	**1**	0	4.7	5.4	4.5	10.1	7	9.4
	2	4.5	0	7.1	6.7	10.8	6.9	10.2
	3	3.5	6.1	0	5.1	6.4	7.4	7.6
	4	2.8	6.6	5.9	0	10.7	10.7	10.7
	5	9.3	11.4	7.6	10.5	0	7.4	5
	6	6.9	7	7.6	9.5	9	0	5.4
	7	8.9	9.3	6.7	11.3	6.2	4.2	0

Travel cost - bus (USD)

		Destination city						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Departure city	**1**	0	21	21	25	38	27	25
	2	13	0	30	32	31	17	25
	3	24	16	0	12	19	32	21
	4	25	24	19	0	21	36	38
	5	22	42	16	39	0	17	11
	6	23	27	16	34	25	0	13
	7	19	19	25	37	28	19	0

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Table 3. Travel times and travel costs for airplane trips

Travel time - airplane (hours)

		Destination city						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Departure city	**1**	0	0.9	1.1	1	2.8	1.8	2.5
	2	0.8	0	1.7	1.8	3.1	1.8	2.4
	3	1.1	1.6	0	1.4	1.7	1.7	1.7
	4	0.9	1.9	1.3	0	2.7	2.8	2.9
	5	2.8	3	1.6	2.8	0	2	1.3
	6	1.9	1.7	1.8	2.8	2.2	0	1.2
	7	2.6	2.5	1.7	2.9	1.3	1.2	0

Travel cost - airplane (USD)

		Destination city						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Departure city	**1**	0	85	160	99	280	194	302
	2	123	0	223	232	385	234	312
	3	162	240	0	202	175	213	209
	4	150	248	197	0	291	295	349
	5	344	327	193	314	0	258	132
	6	202	176	201	281	246	0	181
	7	326	271	230	318	130	174	0

PART I. (20 points)

Assume that you want to minimize your total travel time. Help: for this particular problem, this means that you will travel using only airplanes (not buses).

2.1 (5 points) What is the total travel time (in hours) for the optimal trip (the one that minimizes the total travel time)?

A. 10.3
B. 9.0
C. 8.7
D. 7.6
E. 9.4
F. 11.3

2.2 (5 points) What is the total cost (in USD) associated with the optimal trip (the one that minimizes the total travel time)?

A. 895
B. 1283
C. 978
D. 1076
E. 756
F. 852

2.3 (2 points) For the trip that minimizes the total travel time, which was the <u>first</u> city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.4 (2 points) For the trip that minimizes the total travel time, which was the <u>second</u> city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.5 (2 points) For the trip that minimizes the total travel time, which was the <u>third</u> city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.6 (2 points) For the trip that minimizes the total travel time, which was the <u>fourth</u> city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

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2.7 (2 points) For the trip that minimizes the total travel time, which was the fifth city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

PART II. (20 points)

Assume that now you want to minimize your total travel cost. Help: for this particular problem, this means that you will travel using only buses (not airplanes).

2.8 (5 points) What is the total travel time (in hours) for the optimal trip (the one that minimizes the total travel cost)?

A. 50.4
B. 22.6
C. 47.8
D. 39.7
E. 63.5
F. 57.4

2.9 (5 points) What is the total cost (in USD) associated with the optimal trip (the one that minimizes the total travel cost)?

A. 116
B. 231
C. 158
D. 287
E. 129
F. 174

2.10 (2 points) For the trip that minimizes the total travel cost, which was the first city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.11 (2 points) For the trip that minimizes the total travel cost, which was the second city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.12 (2 points) For the trip that minimizes the total travel cost, which was the third city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.13 (2 points) For the trip that minimizes the total travel cost, which was the fourth city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.14 (2 points) For the trip that minimizes the total travel cost, which was the fifth city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

PART III. (20 points) Graduate students only (or Extra Credit for Undergraduate Students)

Assume that now you want to minimize your total travel cost, but while guaranteeing that the total travel time is less than or equal to 20 hours. In this case, it is necessary to use both buses and airplanes.

2.15 (5 points) What is the total travel time (in hours) for the optimal trip (the one that minimizes the total travel cost using less than or equal to 20 hours)?

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A. 19.9
B. 18.6
C. 19.5
D. 19.8
E. 18.9
F. 20.0

2.16 (5 points) What is the total cost (in USD) associated with the optimal trip (the one that minimizes the total travel cost using less than or equal to 20 hours)?

A. 295
B. 643
C. 435
D. 821
E. 542
F. 718

2.17 (2 points) For the trip that minimizes the total travel cost using less than or equal to 20 hours, which was the first city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.18 (2 points) For the trip that minimizes the total travel cost using less than or equal to 20 hours, which was the second city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.19(2 points) For the trip that minimizes the total travel cost using less than or equal to 20 hours, which was the third city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.20(2 points) For the trip that minimizes the total travel cost using less than or equal to 20 hours, which was the fourth city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

2.21(2 points) For the trip that minimizes the total travel cost using less than or equal to 20 hours, which was the fifth city visited?

A. City 1
B. City 2
C. City 3
D. City 4
E. City 5
F. City 6

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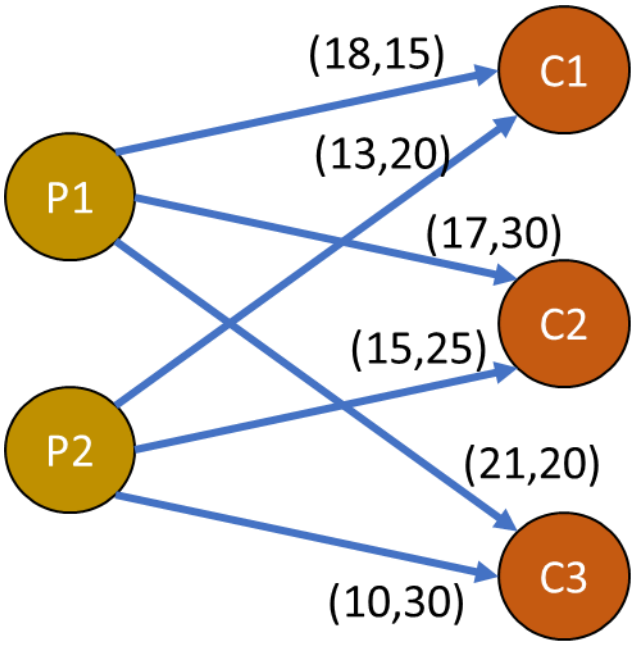
Problem 3. (20 points): Production capacity and distribution

Suppose that you are about to open a company that produces paint. You have built two production plants (P1 and P2) to supply the demands of three nearby cities (C1, C2, and C3), but you still need to decide how much production capacity (in tons) you should assign to each plant.

The figure below indicates the expected demand in each city (in tons). Also, the figure indicates (in parenthesis) the unitary flow cost (dollars per ton) and the maximum capacity (in tons) associated with each arc (respectively).



3.1. (5 points) Considering the information given, how much production capacity should be given to plant P1, so that the final paint distribution cost is minimized?

A. 5
B. 15
C. 25
D. 45
E. 65
F. 85

3.2. (5 points) Considering the information given, how much production capacity should be given to plant P2, so that the final paint distribution cost is minimized?

A. 5
B. 15
C. 25
D. 45
E. 65
F. 85

3.3. (10 points) What is the optimal distribution cost for this problem?

A. 1085
B. 895
C. 995
D. 1135
E. 735
F. 1105

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