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**EXAMINATION INFORMATION PAGE**

**Written examination**

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| Subject code:  **FM3117** | Subject name:  **Industrial Optimization** | |
| Examination date:  **29/11/2019** | Examination time:  **From** **9:00 to 13:00** | Total hours:  **4 hours** |
| Responsible subject teacher:  **Dr. Carlos F. Pfeiffer** | | |
| Campus:  **Porsgrunn** | Faculty:  **Faculty of Technology, Natural Sciences and Maritime Sciences** | |
| No. of assignments:  **Solve all the 5 problems provided.** | No. of attachments:  **None** | No. of pages incl. front page  and attachments: **5** |
| Permitted aids: **Personal notes, exercises, printouts, printed books (all hand notes and printed material).**  **Calculator.**  **NOT ACCEPTED: Cell phones, laptops, tablets, etc.** | | |
| Information regarding attachments: | | |
| Comments: all assignments (problems) have the same value. For problems with multiple tasks, the value of the problem is equally divided among its tasks. **Solve all the problems provided.**   |  | | --- | | **In case you think a problem has a mistake or it is incomplete, explain the information that you think needs to be corrected or completed, assume values for this information, and continue to solve the problem.** | | | |

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| Select the type of examination paper | |
| Spreadsheets | Line sheets  xx |

**Problem 1 (one task).**

A lumber (wood boards) company has three places for sources of wood (A, B, and C) and five markets where wood is demanded (M1, M2, M3, M4, and M5). The selling price of lumber is 1000 nok per cubic meter for all the markets, but the transportation costs vary. Each year, every market should receive at least 5000 cubic meter of lumber, in order to keep them as clients. The following information is also available.

The annual quantity of lumber produced in the three sources of supply are:

|  |  |
| --- | --- |
| Wood Source | Lumber produced in cubic meters |
| A | 30 000 |
| B | 50 000 |
| C | 30 000 |

The maximum amounts of lumber that can be sold at each market are:

|  |  |
| --- | --- |
| Market | Maximum amount that can be received, in cubic meters |
| M1 | 27500 |
| M2 | 30000 |
| M3 | 22500 |
| M4 | 25000 |
| M5 | 20000 |

The company currently transports all of the wood by trucks. The cost of shipment (in nok per cubic meter of lumber) is given in the table below for each combination of supply place and market:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Supply | M1 | M2 | M3 | M4 | M5 |
| A | 51 | 62 | 35 | 45 | 56 |
| B | 59 | 68 | 50 | 39 | 46 |
| C | 49 | 56 | 53 | 51 | 37 |

Task:

Set a linear programing problem to find how much lumber should the company send to each market in order to maximize the raw profit, calculated as the total income of lumber sold minus the total transportation cost. Define any variables you need, and clearly indicate the objective function and all required constraints.

**Problem 2 (one task)**. A plant requires a pump to pump-out waste water, for a project with a total life of six years. Two options are considered:

* Pump Type A costs $1000 dollars, and has a life of 2 years. The cost of installation for a new pump of type A is $200 dollars.
* Pump Type B cost $1500 dollars, and has a life of three years. The cost of installation for a new pump of type B is $250 dollars.

Task:

Using the Net Present Value method, and considering a discount rate (interest) of 10% annual, which type of pump is the best option to use during the life of the project, A or B? Show all your calculations.

**Problem 3 (two tasks)**.

In a plant, a three-way valve mixes two flows of reactants FA and FB, to produce a stream FC, as shown in the following diagram:

FC

FA

FB

All the mass flows are measured using different sensors, with the values reported on the following table (notice that the sensor for FC has a different standard deviation than the sensors for FA and FB):

|  |  |  |
| --- | --- | --- |
| Sensor | Flow (kg/min) | Sensor Standard Deviation |
| FA | 30.5 | 1.0 |
| FB | 90.2 | 1.0 |
| FC | 150.7 | 2.0 |

1. Set up the data reconciliation problem that needs to be solved in order to find the best flow estimates that satisfy the mass balance. Indicate clearly the objective function and the constraints.
2. Solve the problem analytically (by hand), and find the best estimates for the flows. You can use any appropriate method.

**Problem 4 (two tasks).**

It is desired to fit the following experimental data to a nonlinear model with four parameters:

|  |  |  |  |
| --- | --- | --- | --- |
| X1 | X2 | Y | Variance of Y |
| 0.000 | 0.001 | 0.34 | 0.0004 |
| 0.005 | 0.007 | 0.44 | 0.0004 |
| 0.008 | 0.008 | 0.50 | 0.0004 |
| 0.012 | 0.011 | 0.59 | 0.0002 |
| 0.015 | 0.017 | 0.72 | 0.0002 |
| 0.020 | 0.021 | 0.93 | 0.0002 |
| 0.030 | 0.028 | 0.99 | 0.0002 |

The model is given by:

1. Set up an optimization problem using the Least Squares fitting technique to find the parameters of the model (b1, b2, b3 and b4). Indicate clearly the objective function. (Notice that there are two “independent” variables, X1 and X2, and that the variance is different for different experimental values.
2. Explain how would you solve this optimization problem using Matlab or Python (choose one), and answer the following questions: How would you enter the objective function? What functions and options in Matlab or Python would you use?

**Problem 5 (two tasks).**

A student wants to visit his parents in Colombo, Sri Lanka, starting the flight in Oslo. He searches for possible flights, considering the following criteria: total time for the flight, cost, and number of connections (airplane changes), and he gets the information on the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| Flight Option | Total time flight in hours | Cost (NOK) | Number of connections |
| A | 15 | 7000 | 1 |
| B | 25 | 9000 | 2 |
| C | 35 | 7000 | 2 |
| D | 15 | 6000 | 3 |
| E | 25 | 1200 | 1 |
| F | 35 | 2500 | 4 |
| G | 18 | 6500 | 1 |
| H | 19 | 5000 | 2 |
| I | 25 | 8700 | 2 |

1. Considering as desirable criteria a short total time flight, low cost ticket and low number of connections, use the information on the table to obtain the set of non-dominated flights (Pareto front).
2. Explain how the student could use this set (Pareto front) and the information on the table to make a decision.