University of South-Eastern Norway

EXAMINATION INFORMATION PAGE
Written examination

Subject code: **FM3117**	Subject name: **Industrial Optimization**	
Examination date: **29/11/2018**	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: **Choose 4 out of the 5 problems provided.**	No. of attachments: **None**	No. of pages incl. front page and attachments: **5**
Permitted aids: **Personal notes, exercises, print-outs, 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. **Choose and solve ONLY 4 problems out of the 5 provided.**		

Select the type of examination paper Spreadsheets	x	Line sheets	☐

CANDIDATES MUST THEMSELVES CHECK THAT ALL ASSIGNMENTS AND ATTACHMENTS ARE IN ORDER.

Problem 1 (3 tasks).

One of the classic applications of Linear Programming is the *diet problem*. The main goal is to select a set of foods that meets certain daily nutritional requirements at minimum cost. Consider the following table of foods with their nutritional profile for this problem.

Food	Portion Size	Energy (Kcal)	Proteins (grams)	Calcium (mg)	Price ($/portion)	Limit (portions per day)
Oats	28 g	110	4	2	1	4
Chicken	100 g	205	32	12	5	3
Eggs	2 big ones	160	13	54	2	2
Milk	237 cc	160	8	285	1.5	8
Bread	170 g	420	4	22	2	2
Beans	260 g	260	14	80	1.5	2

We want to design a diet containing at least 2000 (Kcal), with at least 55 grams of protein and 800 (mg) of calcium per day. In addition, to provide some variety in the diet, some limits are set for the daily portions of food, for example, the maximum number of portions on the diet for Oats is 4, for Chicken is 3, etc.

a) Defining the number of portions of Oats as X1, portions of Chicken as X2, portions of Eggs as X3, portions of Milk as X4, portions of Bread as X5 and portions of Beans as X6, set up a complete Linear Programing formulation to minimize the cost of diet per day, including all the constraints.

b) Indicate how you would solve it in Excel or Matlab (choose one). How would you define the objective function? How would you define the constraints? What Excel or Matlab function would you use?

c) Assume that first you solve the Linear Programing Problem considering the variables X1, X2…X2 as real numbers (in other words, partial portions are allowed), and then you solve the Linear Programing Problem considering the variables as integers (no partial portions are allowed). Which solution should give a lower cost? Why?

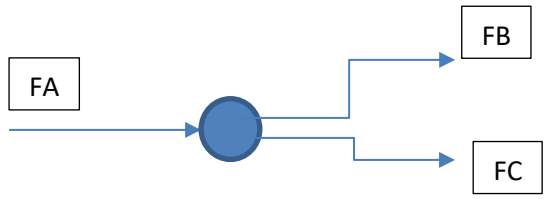
Problem 2 (one task). A person wins 5 million dollars in a lottery, and he is given two options to cash the price:

Option A: Get 3 million dollars now, and the state keeps the other two millions as taxes.
Option B: Get 800 000 dollars now, and 3 additional payments of 800 000 dollars each for three years (the payment is given at the same date every year).

Using the Net Present Value method, and considering a discount rate (interest) of 5% annual, which one is the best option, A or B? Show all your calculations.

Problem 3 (two tasks).

In a plant, the flow FA of water coming into a three ways valve is divided into two different flows, FB and FC, as shown in the following diagram:



All the mass flows are measured using different sensors, and the values are reported on the following table (notice that the sensors have the same standard deviations):

Sensor	Flow (kg/min)	Sensor Standard Deviation
FA	120.7	0.2
FB	110.2	0.2
FC	8.5	0.2

a) 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.

b) Solve the problem analytically (by hand), and find the best estimates for the flows (hint: using the Lagrange's multipliers methods facilitates the solution).

Problem 4 (two tasks).

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

X	Y	Variance of Y
0.000	0.34	0.0004
0.005	0.44	0.0004
0.008	0.50	0.0004
0.012	0.59	0.0002
0.015	0.72	0.0002
0.020	0.93	0.0002
0.030	0.99	0.0002

The model is given by:

$$Y = \frac{b_1}{\left[1 - e^{-(b_2 + b_3 X)}\right]^{b_4}}$$

a) Set up an optimization problem using the Least Squares fitting technique to find the parameters of the model (b_1 , b_2 , b_3 and b_4). Indicate clearly the objective function.

b) Explain how would you solve this optimization problem using Excel or Matlab (choose one), and answer the following questions: How would you enter the objective function? What functions and options in Excel or Matlab would you use? Is it possible that the solution provided by Excel or Matlab is erroneous, even though the numerical methods used by Excel or Matlab indicate no convergence errors? Why? How would you validate that the solution found is reasonable?

Problem 5 (two tasks).

A student in the USA wants to go to a high quality University. However, he also wants to be close to his parent's city, and at the same time he wants to save some money. All the three criteria are very important. After doing some research, he made this table of possible universities:

University	Distance to parents city	Tuition (Dollars per year)	Quality (7 to 10, 10 is best)
A	300	5000	7
B	500	12000	7
C	150	7000	9
D	700	25000	10
E	1000	30000	10
F	800	2500	9
G	320	6500	8
H	615	5000	9
I	322	8700	8

a) Using the information on the table, obtain the set of non-dominated universities (Pareto front).

b) Explain how the student could use this set (Pareto front) and the information on the table to make a decision.