EXAMINATION INFORMATION PAGE

University of South-Eastern Norway

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Subject code: **FM3117**	Subject name: **Industrial Optimization**	
Responsible subject teacher: **Carlos F. Pfeiffer**	Campus: **Porsgrunn**	Faculty: **Faculty of Technology, Natural Sciences and Maritime Sciences**
Assignment given in WISEflow (date and time): 27.11.2020 9:00	Submission time in WISEflow (date and time): 27.11.2020 13:20	
No. of assignments: **5 problems**. Solve **all** the problems. All problems have the same value.	No. of attachments: 0	No. of pages incl. front page and attachments: 5

Aids and collaboration:

Permitted aids: textbook, class notes and course canvas documents. Calculators. All problems requiring calculations **must** be made by hand and calculator **and all the steps must be reported**. If you think there are errors in the exam, explain the errors, propose corrections, and keep answering the problems.

It is strictly forbidden any communication, in any form, with other students taking the exam.

	Yes	No
Is it an individual exam?	☒	☐
Is it allowed to collaborate with other persons?	☐	☒

Description of individual examination and illegal cooperation will be found at [my.usn.no](my.usn.no)

Criteria for the answers:

Font type: Any type. **Solutions by hand allowed.**	Font size:11 or larger **Solutions by hand allowed.**	Line spacing: single or larger. **Solutions by hand allowed**
No. of words (min/max): No limit	Maximum no. of pages excl. front page and attachments: No limit.	

Other important information:

Answer sheets written by hand are acceptable. The student should upload scanned copies of the answer sheets, or phone pictures of the answer sheets in format pdf, jpg or equivalent. The scanned documents and pictures MUST be clearly legible. It is recommended that the students make a quick test taking a picture with the type of sheet and pen/pencil they are using before starting to solve the exam, to warranty that the pictures or scanned documents are legible.

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

Problem 1.

Consider a product mix problem within the context of a simplified oil refinery situation. Suppose that the refinery wishes to blend four petroleum constituents into three grades of gasoline: A, B, and C. The problem is to determine the mix of the four constituents that will maximize profit.

The availability and costs of the four constituents are given on the table below:

Constituent	Maximum quantity available in barrels per day	Cost per barrel
1	5000	$9.0
2	3000	$9.0
3	3000	$3.0
4	2000	$7.0

To maintain the required quality for each grade of gasoline, it is necessary certain maximum or minimum percentages of the constituents in each blend. These are given in the table below, along with the selling price for each grade:

Grade	Specifications	Selling price per barrel
A	Not more than 30% of constituent 1. Not less than 40% of constituent 2. Not more than 50% of constituent 3.	$15.50
B	Not more than 50% of constituent 1. Not less than 10% of constituent 2.	$8.50
C	Not less than 70% of constituent 1.	$13.50

Assume that all other cash flows are fixed, so that the «profit» to be maximized is total sales minus the total cost of constituents.

Task:

Set up a complete linear programing problem to determine the optimal amount and blend of each grade of gasoline, such that the profit, calculated as the total sales minus the total cost of constituents, is maximized. Clearly define and explain all the variables you need, and clearly indicate the objective function and all required constraints. Bounds, equality constraints and inequality constraints are allowed, but notice that ALL the constraints in the formulation must be linear. Fractions of barrels are allowed on the solution.

Problem 2.
A person is considering two options two invest his savings:

Option A)
Buy a house for 3 000 000 nok total, divide it in two apartments, and rent the apartments for a total of approximately 150 000 nok per year (assume the renters pay the whole year at the beginning of each year). Conditioning the house will take one full year and an additional 1 500 000 nok of investment. During this first year, the apartments cannot be rented. In addition, every year after the first year, the person will need to invest 25 000 nok for the house maintenance. The person plans to sell the house at the end of 10 years for $5 000 000.

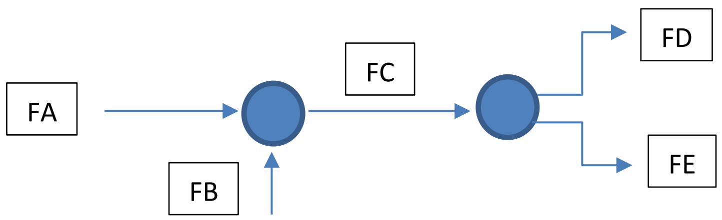
Option B)
Invest 4 500 000 nok in a safe mutual fund with an annual return of 3.5 %, automatically re-investing the interests annually. At the end of ten years, the person retires all the capital plus the interest.

Task:
Using the Net Present Value method, find out what option is the best. Describe clearly all the assumptions and operations that you make. Note: the actual present net values you calculate will depend on the assumptions you make, so it is extremely important that you describe them in detail.

Problem 3.
We want to find three positive numbers whose sum is 120 and whose product is a maximum.

Task:
Set up the problem as a constrained optimization problem and solve it analytically, showing all the steps. Recommendation: utilize the technique of Lagrange multipliers.

Problem 4.
In a plant operating at steady state, you have five mass flows as shown on the figure below:



Assuming that you have only **four** mass flow sensors, all of them with the same variance, complete the following task:

Task:
Choose **four flows** that you would recommend to measure, and use data reconciliation to obtain analytical expressions for the best estimates of the flows where there is redundancy, in function of the measurements. Obtain also an expression to estimate the flow that is not measured, in term of

the best estimates of the others. Indicate clearly your assumptions, procedures and operations. Note: the expressions will be different depending on the flows you choose to measure. If necessary, assume that the variance of all the sensors is 1.

Problem 5.

A manufacturing facility is considering seven projects to improve operations as well as profitability. Due to expenditure limitations and engineering staffing constraints, however, not all of these projects can be implemented. The following table gives projected cost, staffing and profitability data for each project.

Projects alternatives and costs

Project	Description	First-year expenditure ($)	Second-year expenditure ($)	Engineering hours	Net present value ($)
1	Build new production line	500 000	100 000	3000	150 000
2	Modernize old production line	200 000	100 000	2000	130 000
3	Process and sell waste	250 000	50 000	2000	50 000
4	Automate old production line	150 000	0	500	20 000
5	Start a new product	200 000	150 000	5000	200 000
6	Discontinue less profitable product	1000	0	100	5000
7	Import new raw materials from China	170 000	50 000	500	75000

The resource limitations are given by:

- Total First year maximum expenditure $850 000
- Second year expenditure $250 000
- Maximum engineering hours 10 000

In addition, the following management policies must be followed:

- Project 1 or 2 can be selected, but not both of them.
- Project 4 can be selected only if project two is also selected.
- Projects 3 and 7 must be selected together or rejected together.
- If project 5 is selected, project 6 must also be selected.

The objective is to select the projects that maximize the net present value subject to the various constraints and management polices.

Task:

Model the problem as a mixed integer linear or nonlinear programing problem. Explain all your variables, indicating clearly, what variables are continuous, what variables are integer and what variables are binary (can only take the values 0 or 1). Indicate clearly the objective function and constraints in terms of your variables. Indicate also necessary bounds.