Spring, 2022

BACHELOR THESIS IN APPLIED MATHEMATICS

SF100X

1. General information

Each student is responsible for finding a relevant project for their thesis and for acquiring relevant data. The topic of the thesis must be in one of the areas listed below in Section 3. The work is preferably carried out together with another student, but may also be carried out individually. In the former case, the examiner should ensure that each student's effort meets the requirements for an individual bachelor thesis. Groups of three or more students is not allowed. The work will be reported in writing and orally in English or Swedish.

There are a number of mandatory deadlines, listed in Section 2 below. Note in particular that Peer review seminar I and Peer review meeting II are mandatory for all students and that the revised project description (5.) and the report for approval (9.) will receive a pass/fail grade. If the project is failed at either stage, then the final grade will be a fail (F).

Each bachelor thesis must also contain a section on aspects of industrial management in accordance with the instructions provided by the Department of Industrial Economics and Management described in the document `INDEKinfo.pdf` *available on Canvas.*

2. Important dates and deadlines

Date	Time	Room	Description	Type
Jan 18	9:15-10:00	D36	1. Info meeting	Meeting
Feb 11	23:59	Canvas	2. Preliminary title uploaded	Deadline
Feb 18	23:59	Canvas	3. Project description uploaded	Deadline
Feb 23	13:15-17:00	B21,B23,B24	4. Peer review seminar I	Mandatory seminar
Feb 28	23:59	Canvas	5. Revised project description uploaded	Deadline
Mar 24	23:59	Canvas	6. Disposition and skeleton uploaded	Deadline
Apr 25	23:59	Canvas	7. Preliminary report uploaded	Deadline
May 4	13:00-17:00	D36	8. Peer review seminar II	Mandatory seminar
May 10	23:59	Canvas	9. Report for approval uploaded	Deadline
May 17	08:00-17:00	D36	10. Final presentation	Presentation
May 18	08:00-17:00	D36	10. Final presentation	Presentation
May 25	23:59	Canvas	11. Final thesis uploaded	Deadline

1. Info meeting.

2. Preliminary title uploaded. Upload a document on Canvas containing

(1) Tentative title of the thesis
(2) Author(s)

By the deadline for "Preliminary title uploaded", the topic of the thesis and the authors (project group) is final.

3. Project description uploaded. A project description for peer review must be uploaded on Canvas before the deadline. The project description is a brief (1-2 pages, A4) description of the project containing the following:

- *Tentative title*
- *General description of the project.* What is to be done? Why and how? Formulate the research question addressed in your project.
- *Motivation and impact of the project.* Why is the project relevant? For whom is the project relevant? What is the potential impact of your project?
- *Methodology.* What methods will be used in the project? Brief description of methods and relevant reference literature.
- *Data.* Describe the kind of data (if applicable) that will be used in the project and comment on its availability.
- *Feasibility.* Motivate the feasibility of the project. What can reasonably be expected to be achieved? Is the relevant data available? What kind of problems (delays) can you expect to run in to? What new techniques and methods must you learn (identify references)?

Your project description will be evaluated with regards to *Relevance*, *Engineering quality* and *Feasibility.*

4. Peer review seminar I. Each project group will present their project proposal (10 min) and receive feedback from their peers. Each project group will be assigned two other project proposals to evaluate, both in writing and orally.

The evaluation must address the project's *relevance, engineering quality* and *feasibility.* The evaluation must also contain a grade on the scale (1 = insufficient, 3 = sufficient, 4 = good, 5 = excellent) on each of the of the three items *relevance, engineering quality* and *feasibility* and a motivation for the grade.

- The oral feedback is given to the group after their project presentation.
- The written evaluation (approx 1/2 page) must be brought to the Peer review seminar I in 3 copies.

5. Revised project description uploaded. After the Peer review seminar I the authors may take into account the feedback received from their peers and advisor and submit a revised project proposal. The revised project proposal will be evaluated by the advisor (Pass/Fail) and *must be receive a Pass in order for the group to continue their project work.*

6. Disposition and skeleton uploaded. A disposition and skeleton must be uploaded on Canvas. The skeleton is a tentative report containing a complete (or almost complete) table of contents, named sections and subsections along with a brief description of the planned contents of each section/subsection.

7. Preliminary report uploaded. A complete report for peer review must be uploaded on Canvas before the deadline. The report must contain an abstract, introduction, methodology, results, aspects of industrial economics, conclusions and a complete list of references.

8. Peer review meeting II. Each group will be assigned (approximately) two other reports to evaluate. Both in writing and orally. Each evaluation (of approx 1-2 pages) must address the report's *quality of writing* and *engineering/scientific quality* along with suggestions for improvement. The groups meet individually to deliver their feedback.

9. Report for approval uploaded. A complete report, taking into account the suggestions during the peer-review process, must be uploaded on Canvas before the deadline. The report must be complete to such an extent that its contents can be presented at the "Final presentation".

The report will be evaluated by the advisor (Pass/Fail) and *must be receive a Pass in order for the group to present their thesis at the "Final presentation".*

10. Final presentation. The thesis is presented orally in its final form.

11. Final thesis uploaded. Minor corrections may be made to the report after the final presentation and the final thesis, to be graded, must be uploaded on Canvas before the deadline.

3. Project areas and prerequisites

The student must select one of the following project areas in which to pursue the Bachelor thesis.

3.1. **Optimization and Systems Theory.**

Prerequsities: Optimization (SF1811 or SF1841), Systems Engineering (SF2863), and all mandatory courses in mathematics.
Description: The project goal is to identify, model, and solve a problem in optimization or systems engineering relevant to the program. The optimization problem should be within the scope of the course in optimization or systems engineering.

Identify an optimization problem that is relevant to the program and related to an institution at KTH or to a company. Find relevant data from the institution or company. Formulate the optimization problem so that it takes into account the practical conditions and can be solved using methods from the course in optimization. Simplify or reformulate if necessary. Discuss the problem of solvability. Calculate the optimal solution and analyse the results. Depending on the complexity of the problem, the size and accuracy is adapted for practical optimization.

Examples: Portfolio optimization (risk minimization, profit maximization), parameter estimation (modelling of systems), optimization of flows in networks (logistics, planning, transport problems), mixing problems (diet problems, oil refinery). The optimization problem can, for example, be linear or quadratic with or without constraints.

3.2. **Mathematical Statistics.** Within mathematical statistics there are three possible tracks: Applied Mathematical Statistics, Markov Processes and Financial Mathematics.

Applied Mathematical Statistics.

Prerequisites: SF1901 Probability theory and statistics and all mandatory courses in mathematics.

Description. The projects in applied mathematical statistics are directed towards analysis and prediction based on multiple regression analysis. It is *highly recommended* that the student pursuing a project in applied mathematical statistics takes the course

SF2930 - Regression analysis (Regressionsanalys)

in period 3 to learn the appropriate methods.

The projects in applied mathematical statistics can usually be divided into one of the categories *prediction* or *structural interpretation.*

Projects on prediction involves the construction of a multiple regression model, based on real data, and a number of potential explanatory variables. By selection of the explanatory variables an interpretable model is constructed that can be used for forecasting. The analysis

may include transformation of variables, test of normality and heteroscedasticity, censored variables and methods to select the best possible model. Examples include forecasting of real estate prices, wine prices, salaries of professional athletes etc.

Projects on structural interpretation uses mainly the same techniques as mentioned above, but the objective is to investigate if the explanatory variables affects the dependent variable. For instance if physical exercise affects the grades of students. The analysis must address the issue that there may be alternative explanations for observed correlation, for instance, that students who exercise are less likely to smoke and drink alcohol.

Markov processes.

Prerequisites. SF1904 Markov processes, SF1901 Probability theory and statistics and all mandatory courses in mathematics.

Description. Projects on Markov processes are directed towards theory and application of Markov processes and must be based on the theory of Markov processes at the level of SF1904 or higher. Markov processes are used in a wide variety of applications, for instance in bioinformatics, computer science, economics, finance, genetics, linguistics, queueing theory, etc.

In previous years there have been projects on Markov processes directed towards credit risk models in finance, linguistics, and limit order books.

Financial mathematics.

Prerequisites. SF2701 Financial mathematics, SF1901 Probability theory and statistics and all mandatory courses in mathematics.

Description. Projects in financial mathematics must be based on the theory of mathematical finance at the level of the course SF2701 or higher. Projects must adress theoretical or applications of financial mathematics, for instance, pricing of derivatives, model evaluation, model extensions, etc.

4. Supervision

Each project will be assigned a thesis advisor. The thesis advisor will organize the peer review seminars, give feedback to the students and follow the students performance. If needed the advisor may offer individual meetings to assist the students. The extent and format for individual supervision is decided by each advisor.

5. Grades

Grades are given as *Pass/Fail*. The following learning outcomes are expected from students in the course:

(1) demonstrate knowledge of the scientific foundations of the selected topic, applicable methods, overview of recent research and developments as well as deeper knowledge of some aspect of the scientific area.
(2) demonstrate ability to critically search, collect and use relevant information and identify the need for additional knowledge
(3) demonstrate ability to formulate, judge and resolve problems and critically discuss observations, research questions and situations
(4) demonstrate ability to plan and with appropriate methods perform tasks within given time limits
(5) demonstrate ability to engage in oral and written dialogue with different groups to account for and discuss information, problems and solutions

(6) demonstrate ability to make judgements with regards to relevant scientific, societal and ethical aspects
(7) demonstrate ability to with independently within some aspect of the scientific area

The requirements for a passing grade on each of the expected learning outcomes are given as follows:

(1) *Pass:* A study of literature is completed and contains a description of applicable methods within the subject and an orientation of recent research and developments. The chosen method is well motivated and based on scientific or documented experience. Relevant knowledge from courses within the education is used adequately.
Fail: The study of literature is insufficient. Connections to recent research and developments is flawed or missing. Insufficient motivation for the choice of method. The thesis shows lack of knowledge from earlier courses in the education.
(2) *Pass:* The project work is, for the most part, performed independently. Well chosen and established data sources and search methods are utilized. Relevant literature and knowledge is integrated in the thesis. The need for additional knowledge is discussed.
Fail: Relevant literature is missing, at large, or has not been intergrated in the thesis. The thesis does not build on previous knowledge in the subject area. A discussion on further development is missing.
(3) *Pass:* The thesis contains a clear problem formulation and a progression in the construction of the problem formulation. The thesis contains a critical discussion on relevant research questions, observations and situations related to the thesis.
Fail: The problem formulation is flawed as is the progression of it. Relevant Problemformuleringen r bristfllig liksom utvecklingen av denna. Relevant research questions, observations and situations related to the thesis are not discussed in sufficient detail.
(4) *Pass:* The project plan developed during the early stages of the thesis work has been followed. The thesis work is performed within agreed time limits using the methodology that has been agreed upon between student and supervisor.
Fail: The thesis work fails to reach the level that was initially set or the potential new level that has been agreed upon. The intended project plan has not ben followed.
(5) *Pass:* The thesis report is well organized, well formulated and consistent. The citations are relevant, are independently formulated and well integrated. The oral presentation and opposition during the thesis work demonstrates the ability to present and discuss the thesis work with different partners, for instance supervisors, teachers, collaborators, researchers, and other students.
Fail: the contents are not systematically presented and the written report or the oral presentation is difficult to understand. The citations has an unclear purpose, is too close to the original, or collected without a clear connection. The communication or the oral presentation does not display the ability to engage in appropriate scientific discussions.
(6) *Pass:* The thesis work shows good judgement, for instance the ability to explain, motivate, criticize and recommend. Relevant judgements have been made regarding scientific foundations or documented experience. The thesis contains a reflection on societal or ethical aspects unless otherwise motivated.
Fail: Judgements are missing or insufficient. The thesis demonstrates inability to put the study in a larger context. The thesis does not address ethical or societal aspects even if such can be relevant, or a motivation why such aspects are not addressed is missing.
(7) *Pass:* The student is engaged in the project and demonstrates ability to participate in the working culture present within the problem area. The student demonstrates ability

to test and value information in discussion related to the thesis. The student shows initiative and is open for supervision and criticism. The thesis work is performed independently.

Fail: Despite supervision and guidance the student demonstrates lacking ability or unwillingness to participate and cooperate in the present working culture. The student does not contributed with constructive ideas in discussions with supervisors and demonstrates lack of interest in advice and suggestions. The student does not demonstrate ability for independent creative work between the meetings with supervisors.