HL205X Degree Project in Medical Engineering
HL207X Degree Project in Technology and Health

Second cycle, 30 credits

Master Degree Project Guidelines

DEPARTMENT OF BIOMEDICAL ENGINEERING AND HEALTH SYSTEMS
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1. What is a Degree Project?

A degree project enables you to apply and deepen your knowledge, understanding, abilities, and approaches in a substantial research and development project while still in the context of education. The degree project shall be carried out towards the conclusion of your education and imply a specialized study and synthesis of earlier acquired knowledge. The degree project in an engineering programme emphasizes both technical and scientific content and methodological knowledge.

After completing the degree project, you should show the proficiency that is required to work independently as a Master of Science, according to the national qualitative targets for the Degree of Master of Science in Engineering and Degree of Master of Science in the Higher Education Ordinance.

To be eligible for the degree project course, all courses that are required for issuing the Degree of Bachelor and at least 60 credits of courses for second-cycle studies should be fully completed. These 60 credits should include all courses in the program relevant to the degree project. A course in scientific methodology must be finally reported as having been completed with a passing grade.

The degree project course is 30 credits and is graded pass or fail based on the following seven criteria (see them in more detail in Appendix 1):
1. your ability to demonstrate knowledge of the scientific grounds of the subject area, as well as in-depth insight into current research and development and in-depth knowledge of relevant methodology,
2. your ability to search for, gather and integrate knowledge and identify the need for additional knowledge, all with a holistic, critical and systematic approach,
3. your ability to identify, analyse, assess and handle complex phenomena, questions and situations, even with limited information,
4. your ability to plan and, with adequate methods, carry out skilled tasks within a given time frame and evaluate this work,
5. your ability to demonstrate the capacity, both orally and in writing, in dialogue with different groups, to clearly account for and discuss their conclusions and the knowledge and arguments on which these are based,
6. your ability to make assessments regarding relevant scientific, social and ethical aspects, and
7. your ability to demonstrate skills required to participate in research and development work or to independently work in other skilled activities.
2. Finding a Project

The first step in developing the degree project is to find a project you want to focus on. There are several ways in which you can do this.

You can speak with your teachers if they have or know of any projects. You can also search for projects on the KTH projects page (https://www.kth.se/en/samverkan/exjobb/studenter) to see if any projects are of interest to you. You can check with companies and public institutions as they often are interested in additional help and have real-world problems that can be developed into great degree projects. You can even develop a project yourself. In that case, ensure you have all the necessary resources for the work, such as access to data, lab equipment, and a scientific guide. Once you find a project and believe it is a good one that can make the world a better place, consider applying for a grant from the KTH Opportunities Fund.

Before submitting your project idea, there are a few things to consider. Firstly, the project should be relevant to your program's goals. So, if you study Biomedical Engineering, your degree project must be relevant to biomedical engineering. Secondly, your work should be feasible in 20 weeks of full-time work. This means that projects that are too simple or too ambitious are ill-fitted for a degree project. Thirdly, the project must have the potential to fulfil all KTH-common guidelines for master's degree projects, as stated in the previous chapter. Finally, remember that your degree project needs to have both a practical and a theoretical part.

Write a project proposal to get an assessment from the course manager about the suitability of the project, and focus on how your project will allow you to fulfil the grading criteria. Submit a project proposal via this online form: https://www.kth.se/form/project-proposal.

Remember that the decision you will receive on your project proposal is only a rough estimate of whether a project is OK, not a final decision. If the course manager finds that the proposed project does not comply with KTH guidelines for a master’s degree project, you will have to modify your idea or start looking for another project.
3. Writing a Project Description

After your project proposal has been approved, you will be assigned a reviewer. The next step is to write a project description. The description of the reviewer’s tasks and the tasks of other people involved in the degree project course is provided in Appendix 2.

The project description is a document that you write with the help of your scientific supervisor and its purpose is to define your project in more detail. The project description is a job description that you will be evaluated on at the end of your degree project work. Please set specific and measurable goals.

You will receive a template for the project description after approval of the project proposal. An example of a project description can be found in Appendix 3. Make sure you take time to complete the template properly (1 month is recommended). Try to think of your project description as a brief degree project report.

In “Background to the problem and description of the aim of the degree project” you perform a small literature review to explain that your research idea is valid and needs to be explored. Start by describing how the problem or issues have been addressed and why it is important. List what consequences can be identified for different stakeholders. Provide examples of solutions that are already known and what has been done in other contexts. Describe the study context of the problem.

For the part about how to solve the problem, provide an overview of how the theory is already used in the field. List who has used the approach in a similar way to you and explain how you can build on from their work or how your use of this theory differs from the usual application. Additionally, provide an overview of how you understand the chosen theory since there are sometimes multiple ways to interpret theories. Explain which theories you have opted for and why. State the advantages of the approach you have chosen.

Finally, describe the aim of the degree project. The aim is what you intend to achieve at the end of the project. In “Specified objectives and tasks” you need to clearly define your research objectives. The objectives are the actions you will take to achieve the aim. When writing your objectives try to use strong positive action verbs: collect, construct, classify, develop, devise, measure, produce, revise, select, synthesise and others. Objectives should also be S.M.A.R.T., which means they should be:

- **Specific** – be precise about what you are going to do
- **Measurable** – you will know when you have reached your goal
- **Achievable** – do not attempt too much – a less ambitious but completed objective is better than an over-ambitious one that you cannot possibly achieve
Realistic – do you have the necessary resources to achieve the objective – time, access to lab, skills, money, etc?

Time-constrained – determine when each stage needs to be completed. Is there time in your schedule to allow for unexpected delays?

Remember that there is no fixed number of objectives, but you will be required to produce sufficient objectives to be able to measure progress towards meeting the aim.

In “Expected results” enter the expected result for your degree project. What will you have at the end? Is it prototype implementation, simulation, test and evaluation or something else? This part should give a good indication of what you expect to get out of the research. It should connect the data analysis and possible outcomes to the theory and questions that you have raised. It is also a good place to summarize the significance of the work.

It is often useful to write expected results early to focus your reasoning as you build the rest of the description on them.

In “Methodology” you should make clear how you intend to approach the research aim and the techniques and logic that you will use to address it. There are three main types of techniques: data collection, data analysis and Interpretation.

Data collection includes a description of the techniques you will use and the data that you anticipate collecting. Data collection can be literature or document review, prototype building and measuring, working with big data, designing new sensors, conducting interviews or surveys and much more. The emphasis should be to fully describe specifically what data you will be using in your study. Part of the purpose of doing this is to detect flaws in the plan before they become problems in the research.

Data analysis should explain in some detail how you will analyse the data that you assembled to get at the information you need to answer your question aim. It will include statistical or other techniques and the tools that you will use in processing the data. It probably should also include an indication of the range of outcomes that you could reasonably expect from your data collection.

In the interpretation part, you should indicate how the anticipated outcomes will be interpreted to answer the research question. It is extremely beneficial to anticipate the range of outcomes from your analysis, and for each outcome know what it will mean in terms of the answer to your aim or research objectives.

Remember that in part of your degree project report you need to demonstrate your ability to make assessments with regard to relevant scientific, social and ethical aspects. Make sure that some of your steps in the methodology deal with social and ethical aspects.

In “Project and schedule” describe how you plan to structure your time. Try to identify the critical path in your schedule. A critical path is the longest sequence of activities
that must be finished on time for the entire project to be completed. Any delays in critical tasks will delay the rest of the project. Adding some milestones to the schedule will help you to keep track of the progression of your plan.

In “Attachments”, add any other documents that are relevant to your project. This part can be useful in explaining other parts of the project description and can include data samples, relevant documentation or agreements.

In “External participation”, list your contacts from the different organisations that are relevant to the project execution. If you have a scientific supervisor from a company, this person needs to have sufficient authority in the organisation to support your project. The contact person must also have sufficient expertise in the field of application of the degree project.

Before starting the degree project, you must work with the contact person to solve questions about possible compensation, housing, travel and loan of workspace and computer. Before starting, it should also be made clear to the company/organization that the degree project report is not confidential. In connection with this, you must also schedule meetings for checkoffs with the responsible person at the company/organization and share this information with your scientific supervisor, with contact details to the contact person.

You will need a signed supervision agreement form from your main scientific supervisor, which can be found in Appendix 4. This form is mainly needed for you to be safe so that you will always have the support you need. The form also can be downloaded at: https://www.kth.se/social/program/tmlem/page/project-description-2/

In “References”, list all sources used in your project description preferably using IEEE referencing style.

The project description needs to be at least 4-5 pages. The more ‘perfect’ it is, the easier it will be for you to work on your degree project report. At the same time, no one expects you to have a perfect project description. Additionally, you can re-use parts of the text from the project description later in your final degree project report. As part of your work on the project description, you will need to meet with your reviewer and ask for his or her feedback.

Once your reviewer approves the final version of the project description, he or she will send it to a course manager, and you will be registered for the degree project course.
4. During the process

Once your project description is approved, you will be registered for the degree project course by a course manager. Thereafter, you will need to confirm in Ladok that you will be attending the course. You do not need to wait until all formalities are completed to start working on your degree project. The sooner you start, the better.

During your work, you will need to meet with your scientific supervisor from a company or KTH or both. The supervisor may offer you a meeting, but you will also have to take the initiative for supervisor meetings yourself. Book supervision meetings well in advance. The frequency of the meetings depends on your mutual agreement with the supervisor, but it should be frequent enough for you and the supervisor to have a grip on the content and time plan of the project.

Additionally, you will need to take part in a series of seminars at KTH. The main goal of the seminars is to help you write your degree project report and manage the execution of the project on time. The seminars will particularly address the following points about the learning outcomes declared in KTH guidelines for a master’s degree project:

- reflect on, evaluate and critically review one’s own and others’ scientific results,
- be able to document and present one’s work with strict requirements on structure, format, and language usage, and
- be able to identify one’s need for further knowledge and continuously develop one’s knowledge.

Typically, the seminar series consists of six seminars with mandatory homework. Seminars are led by a group supervisor, and you will be invited to the first meeting during which, among other things, the rest of the seminar series will be presented and scheduled.

One of the homework for seminars is to be present at a master’s degree project presentation session and write a review of two of the presentations. Please be aware of the fact that there might be only one presentation the day before your presentation session.

Approximately 10 weeks after you begin your work (the exact deadline will be announced in the seminars), you will have to submit a draft of a degree project report to the reviewer. More details about the draft report will be given in the seminars.

Once you have completed working on the project, you will have to submit your degree project report. Details on how the report should be formatted will be given to you during seminars and briefly described below in this document. Please note that the group supervisor might advise you to attend additional seminars before your final submission.
5. Final report

The degree project report should be written in English. Please discuss with the course manager if you wish to write your report in Swedish. Examples of the front page and a checklist for the writing work can be found in Appendices 6 and 6, respectively. However, some part of the final report deserves closer discussion here.

Title. Note that the degree project report should have the title in both Swedish and English. For the non-Swedish speaking students, it is good if the scientific supervisor and/or reviewer could suggest a translation. Both titles shall be included in the project report. Please also capitalize the important words in the English title (not in the Swedish title).

Cover for degree project report. You need to create the cover of the report (which is the first and last page of the degree project report) using this template: http://intra.kth.se/kth-cover?l=en. The report should thus be put between those two pages. As part of the last page, you will need a TRITA number. You will receive the TRITA number soon after the mid-term meeting with your reviewer. Please note that “TRITA” will appear automatically in the template, so do fill in only CBH-GRU-XXXX. Put an extra blank page after the first cover page, so that your report starts on the right page, and possibly also one before the last page (depending on if your report has an odd or even number of pages). Look at the print preview to make sure it is correct.

Introduction. This chapter briefly describes how the problems or issues have been addressed previously. Why is it important? What consequences can be identified for different stakeholders? What solutions are already known and what has been done in other contexts? What is the research gap that your work will address? Descriptions of the company or study context are often made here. Furthermore, the research aim and objectives can be described at the end of the introduction or in a separate aim chapter.

Background or State of the Art. The background establishes the context of the research. This chapter explains why this particular research topic is essential to understanding the main aspects of the study. In this chapter, you need to outline the developments in the literature that led to the current topic of research concisely. If the study is interdisciplinary, it should describe how different disciplines are connected and what aspects of each discipline will be studied. This chapter must also have a clear theory connection. An essential part is to do a literature study within the field, and also to obtain relevant knowledge about the field within which you will be doing your degree project. As the background includes a lot of information, it can become a long drag, causing the readers to lose interest. To ensure that your background is engaging, you should try to build a story around the central theme of your research.

Methodology. Here, the methods used in the degree project are described, including references to the literature on which the methodology is based. Here the data collection
and analysis work are described. Furthermore, the conditions that existed during the studies are described, particularly information about participants, procedures for experiments or other relevant information. Please describe all methods used to obtain the results presented in the Results section.

**Results.** Reporting of results means that the most significant results of the work are reported. Keep in mind that the degree project work can benefit when extensive, as well as less important but supplementary, results are placed in appendices. The rule of thumb is that all results used in the analysis and the conclusions are reported in the results chapter, while the rest of the results are placed in appendices. The reporting of results must correspond to the issues raised in the aim of the degree project work (this point is very important and a prerequisite for the degree project report to be approved). Please do not repeat the methodology in your results section, and do not present results, for which you did not present the methodology in your Methodology section.

**Discussion.** In the discussion, you can comment on the key results of your work. The discussion should also compare your results with previous work and you can argue, where necessary, for reaching a conclusion. In addition to the discussion of your results, it is advisable to discuss study limitations and how and in what way the chosen method or methods worked and how trustworthy the data were obtained. The reason for this is that readers should be able to form their view of the quality of the raw data in the degree project. This discussion shall directly correspond to the reporting of the initial proceedings concerning the choice of approach, method and measurement techniques made in the planning phase. The methods, data reliability and relevance should also be evaluated. In addition, you can briefly report how the practical work acted, what worked according to plan and what adaptations were made.

**Conclusions.** Conclusions must be directly connected to the aim. It is a balancing act to draw sufficiently far-reaching and general conclusions without going beyond what you have an evidence base for. Recommendations can also be included here.

An abstract of the degree project is the beginning of your report, but the last to be written. It should be no longer than one A4 page. It contains something from all chapters, but with emphasis on the aim, results and conclusions. The abstract must be written in English and Swedish.

Your scientific supervisor or reviewer can suggest a different structure than described here. The number of pages of the degree project reports varies from one project to another but should not exceed 50 pages. Possibly an extended version with more information or appendices can be given to the company/organization.
6. Final steps

Once you have completed your degree project report, there are a few things left before you fully completed the degree project course.

You need to fill out an assessment form where you describe how you have achieved all required criteria to pass the degree project, as seen in Appendix 6. After you complete it, you need to send it to your scientific supervisor(s) to fill out the form too and confirm that your work qualifies for a passing grade. Thereafter, your scientific supervisor sends this file and your final degree project report to your reviewer. Your reviewer and group supervisor, and in some cases other faculty members and examiners, assess your work based on your written report, feedback from your scientific supervisor(s) and your work during the degree project course period.

If they accept your work, you are admitted to an oral presentation and opposition. If they do not accept your work, you will receive feedback on what needs to be improved.

For the oral presentation and opposition, you will prepare a presentation of no more than 25 min. After your presentation, you will discuss your project with a student opponent and a faculty opponent (your reviewer or examiner), who will each have 15 minutes to ask questions and make comments. You will also be assigned another degree project report to prepare a student opposition, write a written review of the report based on the template in Appendix 8 and prepare several questions for oral opposition.

After the presentation of your work, you will receive comments and potential requests for improving your degree project report. You will have to comply with all requests for changes in your report within 3 weeks of receiving the review and resubmitting the final version of your report for final approval to your reviewer. The reviewer might also judge your work to be insufficient. If this will happen, you will be informed of what actions need to be taken.

Your reviewer, after the final approval of your degree project report, will send your work to the examiner. If the examiner approves the report as well, you will be asked to upload your report to the KTH DiVA portal (Digitala Vetenskapliga Arkivet) as instructed in Appendix 9.

When the upload in DiVA is correct, the course manager will record your grade in Ladok, and you are officially done with the degree project course.

Provided that you have passed all courses in the program, and have completed all the steps above satisfactorily, you are now eligible to apply for your degree. The application for a degree certificate (ansökan om examen) can be found via Personal menu/Services (Personliga menyn/Tjänster). Contact Student Office if you have more questions.
Appendix 1

KTH-common guidelines for master’s degree projects state that after completion of the degree project, the student should be able to:

1. Demonstrate knowledge of the scientific grounds of their chosen subject area, as well as in-depth insight into current research and development and in-depth knowledge of relevant methodology

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<th>criteria for PASS</th>
<th>criteria for FAIL</th>
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<td>The literature study is well executed. Current research and development with bearing on the work are shown clearly. The student’s choice of method is well-founded, based on science or proven experience, and evaluated against other methods. Relevant knowledge from the courses of the programme has been adequately applied.</td>
<td>The literature study is inadequate. Links to current research and development are lacking or insufficient. Unsatisfactory justification for the chosen method or evaluation thereof. The work shows a lack of knowledge from previous courses in the programme.</td>
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2. Demonstrate the ability to search for, gather and integrate knowledge and identify their need for additional knowledge, all with a holistic, critical and systematic approach

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<th>criteria for PASS</th>
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<tr>
<td>The task of the degree project is handled independently and systematically, based on critical analysis and synthesis of relevant literature. The work demonstrates a holistic approach. Carefully selected databases and search tools are used. The need for additional knowledge is discussed.</td>
<td>There is a significant lack of relevant literature, or it has not been integrated into the work. The literature is handled with an uncritical approach. The work is not based on existing knowledge in the area. There is no discussion on the development of the work.</td>
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3. Demonstrate the ability to identify, analyse, assess and handle complex phenomena, questions and situations, even with limited information

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| Relevant complex phenomena, questions and situations are identified in the degree project. The work shows clearly that these have been handled and analysed well, despite the available information is limited. Assessments linked to the questions posed in the | Complex phenomena, questions or situations are not formulated, handled or analysed in the degree project. The work shows the lack of a holistic approach to the problem or is limited without the motive to reduce the complexity of the task. There is a lack of relevant
4. Demonstrate the ability to plan and, with adequate methods, carry out skilled tasks within a given time frame and evaluate this work

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<td>The schedule drawn up at the start of the degree project has been followed. Skilled work is carried out within the time frame – and with the methods – agreed on. Any changes in the plan or the work are established via an agreement between the student and the scientific supervisor. Assets and limitations in the work carried out are clearly defined.</td>
<td>The work is not of the standard initially set or, where applicable, the new standard agreed on. There is no critical evaluation of the student's work. The agreed plan has not been adhered to in terms of schedule and methodology.</td>
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5. Demonstrate the capacity, both orally and in writing, in dialogue with different groups, to clearly account for and discuss their conclusions and the knowledge and arguments on which these are based

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<td>The report is well-organised, well-formulated linguistically and coherent. Good argumentation has been provided for the conclusions. The summary of sources is relevant, independently formulated and well-integrated. Oral presentation and opposition, as well as communication during the course of the work, demonstrate the ability to present and, while being open to feedback, discuss the work and conclusions with various parties such as clients, supervisors, teachers, researchers and students.</td>
<td>The content is not presented systematically, and the text or the oral presentation is difficult to understand. The argumentation for the conclusions is inadequate. The summary has no clear direction, is too close to the source, or lacks coherence. The written report is not well formulated linguistically or coherent. The ongoing communication or the oral presentation does not demonstrate sensitivity, clarity or the ability to discuss the work and conclusions.</td>
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6. Demonstrate the ability to make assessments with regard to relevant scientific, social and ethical aspects

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<td>The degree project demonstrates assessment skills, such as being able to explain, justify, criticise and recommend. Relevant (i.e., subject-related)</td>
<td>Assessments are missing or inadequate. The work shows an inability to put the study in a broader context. The degree project does not address ethical or social aspects</td>
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assessments with scientific grounds or proven experience have been made in the degree project. The degree project contains reflections on social and ethical aspects, where these are not deemed irrelevant. aspects, even though these may be relevant to the project, or there is no justification for why these aspects were not addressed.

7. Demonstrate the skills required to participate in research and development work or to independently work in other skilled activities

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<td>The student immerses themselves in the task very well and demonstrates the ability to participate in the work culture prevailing in the environment in which the task is to be performed. The student demonstrates the ability to test, evaluate and even reject ideas and solutions in discussions concerning the task. The student shows the capacity to take initiative and is open to supervision and criticism. The degree project is largely carried out independently.</td>
<td>Despite supervision and guidance, the student does not show the ability or willingness to participate and collaborate in the prevailing work culture. The student does not bring constructive ideas to discussions with supervisors and shows a lack of interest in advice and new suggestions. The student does not demonstrate creative work of their own between supervisions.</td>
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Appendix 2

The roles in a degree project

Role of a student

You have the most important role in the work. All other people are there to support you, but all the burden of the work is on you. Here are the tasks that you as a student in the degree project course need to do:

- Learn about prerequisites and rules for the degree project,
- Find a suitable degree project and a scientific supervisor,
- Produce together with the scientific supervisor a project proposal,
- Produce together with the scientific supervisor and a reviewer a project description,
- Attend group seminars,
- Do the work,
- Write a report,
- Present mid-term progress to the reviewer meeting,
- Submit the final report with a final assessment form to the scientific supervisor
- Oppose another student’s work,
- Give an oral presentation,
- Publish the report on DiVA.

Role of a course manager

A course manager mainly helps with the administrative side of the work, such as registration to the course and registration final results, helping with finding a reviewer and group supervisor and helping in cases of delay. The course manager is allowed to be your scientific supervisor, group supervisor or reviewer. The tasks of the course manager are:

- Review the project proposal: judges whether the project follows the guidelines for the programme and that the student fulfils the required prerequisites,
- Suggest a reviewer,
- Check that the project description is filled correctly,
- Archive the project description,
- Registratate the student in Ladok and Canvas,
- Suggest a group supervisor,
- Obtain the TRITA number for the project degree report,
- Schedule the oral presentations (with the opposition),
- Announce oral presentations within the department,
• Report results of the degree project course in Ladok,
• Keep the information about the course up to date.

Please contact the course manager in the following cases:
• you want to pause or terminate the project,
• there is a deviation from the time plan in the project description with more than 4 weeks,
• there are other major changes in the project description or deviations from it,
• you need to change a group or scientific supervisor,
• you take on work that can affect the time plan,
• you experience a lack of support from the supervisor or in the working environment,
• there is a conflict between you and the supervisor.

Role of a reviewer
As part of your process of developing your degree project, you will be assigned a reviewer, who ensures that your work has a sufficient scientific foundation. This means that the reviewer will help you to produce a degree project of sufficient quality. The reviewer cannot be a scientific supervisor or the group supervisor. The tasks of the reviewer are the following:
• Review the project proposal,
• Meet with you to discuss the project description,
• Check the feasibility and the scientific relevance of the project description,
• Approve the project description,
• Meet with you to discuss the mid-term progress to suggest eventual adjustments,
• Approve the mid-term progress,
• Take part in an assessment of the final degree project report according to KTH guidelines,
• Send the final report to the course manager for the preparation of the oral presentation,
• Attend the oral presentation and act as a faculty opponent,
• Provide feedback on the final report,
• Approve the final report when the feedback has been processed.
Role of a group supervisor

A group supervisor is a person that leads the group seminars. The group supervisor helps with structuring your report by discussing good practices and providing some feedback on your report. If your project gets delayed your group supervisor may change during your time in the degree project course. The group supervisor cannot be your reviewer. The duties of a group supervisor are the following:

- Schedule and lead the seminar series,
- Check upon student's progress and give feedback and suggestions,
- Take part in an assessment of the final degree project report according to KTH guidelines.

Role of a scientific supervisor

A scientific supervisor is a person in KTH or a company with whom you are doing a project and with whom you have has the most contact during your degree project. While the scientific supervisor should be there for support, you are encouraged to work independently. The scientific supervisor and the course manager or the examiner can be the same person. The scientific supervisor has the following responsibilities:

- Be active at the working site where the thesis project is carried out and have competence in the area,
- Produce together with the student a project proposal and a project description,
- If agreed upon, provide the working site and working tools according to the project description,
- Guide in the daily work with technical competence and advice,
- Help the student to stick to the time plan,
- Assist in writing the report and gives feedback on it.

Role of an examiner

An examiner is responsible for the degree project course within the educational program according to the Higher Education Ordinance. The examiner can be your reviewer or the scientific supervisor, but not both the reviewer and the scientific supervisor at the same time. The examiner has the following tasks:

- Preapprove a list of possible reviewers,
- Preapprove a list of possible group supervisors,
- If possible, attend a meeting with a reviewer and a student to discuss the project description,
- If possible, attend a meeting with a reviewer and a student to discuss the mid-term progress,
- Take part in an assessment of the final degree project report according to KTH guidelines,
- If possible, attend the oral presentation,
- Give the final approval of the work.

**Brief workflow model of different roles**

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<tr>
<th>Student Action</th>
<th>Course Manager</th>
<th>Reviewer</th>
<th>Group Supervisor</th>
<th>Scientific Supervisor</th>
<th>Examiner</th>
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<td>Find a project</td>
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<td>Confirm</td>
</tr>
<tr>
<td>Submit project proposal</td>
<td></td>
<td>Find a reviewer</td>
<td>Approve proposal</td>
<td></td>
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</tr>
<tr>
<td>Develop project description</td>
<td></td>
<td>Inform student</td>
<td>Approve and inform the course manager</td>
<td></td>
<td>Approve</td>
</tr>
<tr>
<td>Inform the student, register in Ladok and Canvas, and assign a group supervisor</td>
<td></td>
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<td></td>
<td>Inform about seminars</td>
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<tr>
<td>Attend seminars</td>
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<td>Lead seminars</td>
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<tr>
<td>Keep contact with the scientific supervisor</td>
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<td>Keep contact with the student</td>
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<tr>
<td>Submit mid-term progress to the reviewer</td>
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<td>Discuss mid-term progress</td>
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<tr>
<td>Student</td>
<td>Course manager</td>
<td>Reviewer</td>
<td>Group supervisor</td>
<td>Scientific supervisor</td>
<td>Examiner</td>
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<td>with the student</td>
<td>with the student</td>
<td>with the student</td>
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<td>Report progress to the course manager</td>
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<td>Obtain TRITA number</td>
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<td>Submit final report</td>
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<td>Assess the final report</td>
<td>Assess the final report</td>
<td>Assess the final report</td>
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<td>Report decision to course manager</td>
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<td></td>
<td></td>
<td>Plan presentation date and opposition</td>
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<tr>
<td>Prepare opposition report</td>
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<tr>
<td>Present work</td>
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<td></td>
<td>Attend an oral presentation and function as a faculty opponent</td>
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<td></td>
<td></td>
<td>Supplies a list of changes to student</td>
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<td>Fix the final report as instructed</td>
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<td></td>
<td></td>
<td>Approve the final report and sends it to the examiner</td>
<td></td>
<td></td>
<td>Approve the final report and sends it to the course manager</td>
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<tr>
<td></td>
<td></td>
<td>Inform student</td>
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<tr>
<td>Student</td>
<td>Course manager</td>
<td>Reviewer</td>
<td>Group supervisor</td>
<td>Scientific supervisor</td>
<td>Examiner</td>
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<tr>
<td>Upload work to DiVA</td>
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<tr>
<td>Record results in Ladok</td>
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</tbody>
</table>
Appendix 3
Example of Project Description

<table>
<thead>
<tr>
<th>Student name</th>
<th>Personal identity no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sven Svenson</td>
<td>991231-1234</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course name</th>
<th>Reviewer</th>
</tr>
</thead>
<tbody>
<tr>
<td>HL205X Degree Project in Medical Engineering</td>
<td>Rodrigo Moreno</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preliminary title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of a real-time autofocus algorithm for Perimed’s Perfusion Speckle Imager (PSI)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Background to the problem and description of the aim of the degree project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcirculatory tissue blood perfusion consists of the local fluid flow through the capillary network and extracellular spaces, and it is behind the transport of oxygen, nutrients, and waste products. Perimed’s Perfusion Speckle Imager (PSI) is an instrument that measures microcirculatory blood perfusion in living tissues [1]. It is based on the Laser Speckle Contrast Analysis (LASCA) technique, an imaging method where the object is evenly illuminated by laser radiation and the backscattered light interferes to form a pattern called the “speckle” [2]. The speckle pattern is imaged on an industrial camera sensor with an objective lens. By using special image processing, the speckle contrast can be monitored to provide information about blood perfusion in the tissues.</td>
</tr>
</tbody>
</table>

When measuring with PSI, it is essential for the acquired image to be sharp, to probe fine details of the object under study, and to guarantee high image quality. Acquiring sharp images becomes particularly important to distinguish small details both for clinicians and researchers, for example when a small vessel or a mouse brain is imaged. Autofocus (AF) process is used to control the objective lens parameters so that the image is always brought to the focal plane, where image sharpness is the highest [3].

PSI instrument consists of a measurement Laser (CW laser diode emitting at 785 nm), indicator laser (red laser at 635 nm), measurement camera (CMOS sensor), power zoom objective lens, and optical filters. The power zoom lens has 3 motors (Zoom motor, Focus motor, and Iris motor). The 3 motors are integrated internally inside the body of the lens, and it is possible to control them via the measurement camera hardware. By adjusting the focus motor of the objective lens, it is possible to get sharp images at given zoom and distance values. The role of the AF procedure in PSI is to find the best focus position corresponding to the highest sharpness level of the acquired images. The implemented AF method is based on
pre-calibration of the focus in the production phase to generate curves of the best focus position as a function of the distance for a given zoom. The fitting coefficients of the curves are saved in the EEPROM of the main electronic board of the PSI. The main software PIMSoft that controls the PSI will calculate the best focus position by using the fitting coefficients and send a command to the lens focus motor to get a sharp image. The weakness of the implemented AF is the difficulty to get always sharp images at any zoom and distance due to the fitting error, distance measurement error (done by PIMSoft), and the calibration curves don’t cover all zoom values and all distances.

The main goal of the project: The goal of this project is to develop a real-time AF algorithm for PSI, with an efficient evaluation of a robust passive AF procedure based on image processing techniques. The algorithm should be as fast as possible (execution time is less than 10 seconds), considering the hardware limitations. The performance and the ability of the AF algorithm to set the lens in the proper focus position will be compared against Perimed’s focus pre-calibration. The final AF function will optimally drive the hardware, incorporating image acquisition, image processing and image quality assessment.

**Specified objectives and tasks**

1. Identify the best autofocus algorithms and techniques employed in different applications
   a. What are best practices?
   b. What are the biggest challenges?
   c. What criteria are used to determine the right algorithm or technique?
2. Apply algorithms and techniques in MATLAB environment and perform experiments
   a. What are experiment settings?
   b. What are key performance data that I need to observe?
3. Improve the algorithms
   a. What are acceptable focus ranges?
   b. What is the balance between doing it faster or doing it with better quality?
   c. How to deal with noises?
4. Investigate the effect of the laser speckle
   a. Does laser speckle affect images?
   b. How to find the best focus position considering the degradation of the details in an image?
5. Finalize AF algorithm development for PSI
   a. How previous tasks can be combined and adapted into a single real-time AF function?
   b. What results give AF function when it is tested against external mechanical noise?
   c. What results give AF function when it is tested in a real-life scenario?

**Expected result**
A real-time AF algorithm for PSI

Methodology

1. Literature Review: literature research study concerning autofocus algorithms and techniques employed in different applications (e.g., mobile phone cameras and microscopy systems), the state-of-the-art image quality assessment and blind image sharpness methods (BISA) [4], laser speckle phenomenon and how to deal with it. More advanced methods are also considered.

2. Programming and experimental work: The development of the considered techniques will be performed in this phase in a MATLAB environment. Sensitivity, computational simplicity, execution time, and coherency (monotonicity) of the method are the main parameters to be evaluated. Testing is carried out through experiments on both static diffuse objects and on human skin tissue by using a PSI imager head. Images without laser speckles are acquired by using a uniform illumination source (LED) at 785 nm. The goodness of the algorithms is also assessed in two ways: (a) by comparing the obtained BFP with the one calculated from the focus pre-calibration method and (b) by monitoring the sharpness of the acquired image at the obtained BFP.

3. Optimization of the selected algorithms: Given the time constraint posed by a real-time AF procedure, one cannot afford to acquire many images to process and compare. The optimization is done in terms of selecting the focus ranges and performing a fast scan to get a good result in a shorter time. Noise resistance has to be guaranteed and the scorer (image sharpness assessment criterium) from phase 2 is employed.

4. Laser speckle treatment: The effect of the laser speckle on the images is investigated. Laser speckle plays the role of the signal for PSI, but it is considered as a noise [5] for AF purposes. The speckle degrades the details in an image and makes it difficult to find the best focus position. It is unavoidable to filter out the speckle, therefore several digital filters are tested. Results are shown with and without filtration.

5. Real-time AF procedure: After performing the previous steps, the acquired knowledge and algorithm’s pieces are combined and adapted into a single real-time AF function to perform the real-time AF procedure for PSI. The function has to be optimised and tested against external mechanical noise. The function is also tested in a real-life scenario.

6. Ecological and social impact of laser speckle: Once the development of the algorithm is complete, the assessment will be conducted to determine how this design affect environment around. Additionally, the impact of society, especially from different social levels, will be addressed.
### Project and schedule

<table>
<thead>
<tr>
<th>Week</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>Literature review</td>
</tr>
<tr>
<td>3-6</td>
<td>Programming and experimental work. Writing Thesis report.</td>
</tr>
<tr>
<td>6</td>
<td>Milestone: working model</td>
</tr>
<tr>
<td>14</td>
<td>Milestone: working laser treatment</td>
</tr>
<tr>
<td>20</td>
<td>End of the Thesis work.</td>
</tr>
</tbody>
</table>

### Attachments

- Supervision agreement

### External participation

- Olof Olofsson Optical AB

### References

1. [http://www.perimed-instruments.com/content/pericam-psi-nr/](http://www.perimed-instruments.com/content/pericam-psi-nr/)
Appendix 4

Supervision agreement

I hereby certify that I will serve as scientific supervisor for__________________________

__________________________________________________________________________

The related thesis work will take place over the following period:
start date:__________________________ end date:__________________________

The core tasks of the project can be performed within the period above:
□ Yes □ No

All materials and equipment needed for the project are currently available to the student:
□ Yes □ No, but will be available on:__________________________

The student will have access to competent supervision
□ Yes □ No

I am aware that the resulting thesis will be publicly defended and that all outcomes of the
student’s work (methods, results, etc.) will be published in the KTH-DiVA public archive:
□ Yes
Supervisor name: __________________________ Date: __________________________

Signature:

__________________________________________________________________________

1 This includes supervision by persons other than the individual signing this form. However, the
signatory will bear the responsibility of ensuring that supervision is offered.
Appendix 5
Examples of a front page

Quantification and Detection of Motion Artifacts in Laser Speckle Contrast Imaging
DENNIS AMPHAN

Degree Programme in Medical Engineering
Date: June 27, 2022
Supervisor: Ingemar Fredriksson
Reviewer: Rodrigo Moreno
Examiner: Matilda Larsson
School of Engineering Sciences in Chemistry, Biotechnology and Health
Host company: Perimed AB
Swedish title: Kvantifiering och detektering av rörelseartefakter inom laser-speckle-kontrast-avbildning
TRITA: CBH-GRU-2022:006

The thesis was performed at Perimed AB

Quantification and Detection of Motion Artifacts in Laser Speckle Contrast Imaging
Kvantifiering och detektering av rörelseartefakter inom laser-speckle-kontrast-avbildning
DENNIS AMPHAN

TRITA: CBH-GRU-2022:006
Supervisor: Ingemar Fredriksson
Reviewer: Rodrigo Moreno
Examiner: Matilda Larsson
School of Engineering Sciences in Chemistry, Biotechnology and Health
KTH Royal Institute of Technology

Quantification and Detection of Motion Artifacts in Laser Speckle Contrast Imaging
by
Dennis Amphan

Master Degree Project
School of Engineering Sciences in Chemistry, Biotechnology and Health
TRITA: CBH-GRU-2022:006

Supervisor: Ingemar Fredriksson
Reviewer: Rodrigo Moreno
Examiner: Matilda Larsson
Swedish title: Kvantifiering och detektering av rörelseartefakter inom laser-speckle-kontrast-avbildning

Quantification and Detection of Motion Artifacts in Laser Speckle Contrast Imaging

Dennis Amphan

Master in Medical Engineering
Date: June 27, 2022
Supervisor: Ingemar Fredriksson
Reviewer: Rodrigo Moreno
Examiner: Matilda Larsson
Swedish title: Kvantifiering och detektering av rörelseartefakter inom laser-speckle-kontrast-avbildning
TRITA: CBH-GRU-2022:006
KTH Royal Institute of Technology
Appendix 6

Checklist for finishing the degree project report

Scope of the report
□ Does the report provide sufficient information for an assessment of the entire degree project report?
□ Are all choices (i.e., between alternative methods/models, delimitations, alternative designs) justified in the report?

Outline and layout of the report
□ Is the presentation logically divided into chapters and paragraphs?
□ Is the purpose well formulated and do the conclusions correspond to the purpose?
□ Is the distribution of tables and figures between running text and attachments well balanced?

Readability of the report
□ Can the reader clearly distinguish between what are facts and what are opinions?
□ Can the reader clearly distinguish between the views of the authors and others?
□ Are all unnecessary repetitions of reasoning, argument etc deleted?
□ Are figures and tables clear, self-explained and legible?
□ Is the report technically readable?

Language processing
□ Are all concepts explained/defined the first time they occur?
□ Are all recurring expressions consistently used?
□ Is the right tense (past tense or present tense) used everywhere?
□ Is every sentence logically constructed?
□ Are sentences of reasonable length?
□ Are used abbreviations generally accepted and explained? (Abbreviation dictionary)
Are abbreviations, typographical characters etc. consistently used? (ex: one per cent, per cent., %)

Are the spelling and hyphens correct? (use spelling software)

Are all the tables and figures mentioned in the text?

Reference Management

Is it clear who is behind the different views and knowledge presented in the text?

Can all data be traced to a specific source?

Specific information on figures

- Figures can give an immediate picture of rather complex relationships that would be difficult to see in a table, e.g., interactions and non-linear relationships.

- Use the same format for all figures of the same type in a report, e.g., the same symbols for different subgroups.

- The figure text should be under the figure

- In the text, refer to all figures with figure numbers. Use Arabic numerals.

- The figurative text should make the figure understandable without reading the text.

- If a variable is treated as an independent variable (cause variable), it should be added to the x-axis and the dependent variable (power variable) added to the y-axis.

Specific information on tables

- The table should be arranged so that the results are visualized as simple and quick.

- Keep in mind that it is easier to compare numbers in a column than in a row.

- By varying the distances between columns or rows, one can make it clear which values belong together and should be compared.

- Rounded numbers make reading the table easier. Decisions about decimal places should however be related to the precision of the measurement.

- Only in exceptional cases can page breaks be made in the table.

- Abbreviations can be explained in notes directly below the table.
Appendix 7

Final assessment form

Instructions for student
For every assessment, item look at the requirements. If you think that you meet the requirements, provide a short explanation of how in column "Self-evaluation". If you meet the requirement for every item, send the form to your scientific supervisor(s) together with the written degree project report.

Instructions for scientific supervisor(s)
Review the student’s report and the evaluation and add your comments to comment to the student’s self-evaluation. When you agree with the student’s assessment and all objectives are fulfilled, the main scientific supervisor needs to send the assessment form and the report to the reviewer. If some of the objectives are not OK, send the form back to the student and give feedback on what needs to be corrected. The process goes again from the start.

<table>
<thead>
<tr>
<th>Assessment component</th>
<th>Requirement</th>
<th>Self-evaluation</th>
<th>Supervisor’s comment on the student’s self-evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>The studied problem is clearly defined, scientifically relevant (sufficiently complex) and possible to evaluate. Conditions and limitations described.</td>
<td></td>
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</tr>
<tr>
<td>Background</td>
<td>The scientific field of work is well introduced. The background contains a written review of previous research and development, and the student’s work is designed in accordance with the conclusions of this review. Work that is related to the state of the art of knowledge is described.</td>
<td></td>
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</tr>
<tr>
<td>Methodology</td>
<td>The selected methods are adequate scientifically or from an engineering perspective, well presented and applied correctly. Relevant knowledge from the education is used correctly.</td>
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<tr>
<td>Results</td>
<td>The results from the work are accurate, non-trivial and newsworthy.</td>
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<tr>
<td>Evaluation</td>
<td>The work has been evaluated properly with appropriate methods.</td>
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</tr>
<tr>
<td>Discussion, conclusions</td>
<td>The conclusions are well-founded and accurate. There is a clear link between the findings, hypotheses and results. Future development of the work is discussed and the need for additional studies is identified.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainability and ethics</td>
<td>Reports issues and motivates the work and discusses the results from different perspectives, focusing on economic, social and ecologically sustainable development and ethical aspects or explain clearly and accurately argues why this is not relevant for the specific degree project.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Societal aspects</td>
<td>Clearly reports the social relevance of the assignment and its outputs, by clearly discussing for whom and why the work and its results are interesting in a broader perspective.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Language, formalities, structure, terminology</td>
<td>The report is well structured, with a clear statement of work, results, and conclusions, with clear analysis and well-backed-up arguments. The structure, language, references and layout of the report follow the technical/academic standards. Spelling, grammar and formatting are at a good level. Results are presented in a structured way and are clearly illustrated (figures, tables, diagrams, etc.). The report contains English and Swedish abstracts.</td>
<td></td>
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</tr>
</tbody>
</table>
Appendix 8

Opposition report

You will be assigned a degree project report that you need to carefully read and write an opposition report. The written opposition is about 1-2 pages. Use the following questions as a guide to ensure a holistic assessment of the work.

• Do you consider that the report title justly reflects the contents of the report?
• Is the problem clearly defined?
• Is the study important? Does it have important implications? How well does it relate to Medical Engineering?
• Do the literature studies relate to the problem definition? Are there enough depth and quality in the reference list? Are the references up to date (still valid)? Does the author have a critical attitude towards the referenced literature?
• Are the concepts and terms clearly defined?
• Is the language clear and easy to follow?
• Does the literature study contribute to a further refinement/reinforcement of the problem definition?
• What method(s) of investigation has been used? Has the author argued for her/his choice of methods scientifically? Are there any alternatives? Does the method of investigation lead to reliable results?
• How are the results presented? Is the presentation clear, concise and understandable?
• How do the results relate to the theory/literature presented earlier?
• What results conform and what differ? Are the results statistically/logically valid?
• Are the author’s conclusions clearly stated, clearly motivated and well-founded? Do the conclusions relate to the problem definition? Are the conclusions precise? Do the conclusions follow from the results? Do you consider the author’s conclusions to be credible?
• Are the goals/objectives of the study fulfilled? What is your estimation of the news value of the work?
Appendix 9

Instructions for uploading your degree project report on to KTH DiVA database

1. Log in to Diva: https://kth.diva-portal.org/dream/login.jsf
2. Click Add publication/Upload files.
3. Choose the publication type “Student thesis” from the menu.
4. Fill in the author fields marked in red below. For Department, unit or programme: click Choose Organisation and write there “Biomedical Engineering and Health Systems”.

If the degree project has been done elsewhere (industry or another university/research institute) check the box “Yes” below External cooperation and fill in the name of the host institution.
5. Fill in the English title of your report as Title and the Swedish title as Alternative title. Choose the language from the menu for both titles.

6. Make the following choices from the menus and fill in the year and number of pages. Note that you should select “Master of Science– Medical Engineering”.

- Title
  - Main title: Write English title here
  - Subtitle:
  - Language: English

- Alternative title
  - Main title: Write Swedish title here
  - Subtitle:
  - Language: Swedish

- Degree
  - Independent thesis Advanced level (degree of Master (Two Yea
  - University credits: 30 HE credits
  - Educational program: Master of Science - Medical Engineering
  - Subject / course: Medical Engineering

- Content category
  - Artistic work

- Other information
  - Year: 
  - Number of pages: 
7. Select TRITA-CBH-GRU as your Series and fill in your TRITA number in No. in series.

8. Select "Medical Engineering" as the National subject category. Go to https://ep.liu.se/hsv_categories, enter there your abstract and find 2-3 more subject categories that are relevant to your work.

6. Fill in the supervisor fields marked in red below. If your scientific supervisor is from KTH, first try to look up your supervisor by clicking on Connect authority record. Note that this should be your scientific supervisor and not your group supervisor.

11. Fill in the examiner fields marked in red below. Click Connect authority record and select Matilda Larsson (HL205X) or Sebastiaan Meijer (HL207X).

12. Click “continue” and upload your degree project report in pdf format on the next page. Choose “Make freely available now (open access).”

13. Click” continue” and review that all information is correct.

14. Click the submit button.