



## Individual study plan for postgraduate education

**LUNDS UNIVERSITET**

Lunds Tekniska Högskola

### Research subject: Automatic Control (TEFRTF00)

Lunds Tekniska Högskola

**Registration number:**

**Name:** Nils Vreman

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**Email:** nils.vreman@control.lth.se

**Department:** Department of Automatic Control

**Main supervisor:** Martina Maggio

**Assistant supervisor:** Anton Cervin

**Assistant supervisor:** Karl-Erik Årzén

**Representative of the department:** Pontus Giselsson

**Director of studies:** Pontus Giselsson

**Head of Department:** Anders Rantzer

**Latest work planning meeting:** 2022-11-23

**Participants of planning meeting:** Nils Vreman, Anton Cervin, Karl-Erik Årzén, Martina Maggio, Pontus Giselsson

**Entered into the database:** 2023-01-19 10:07:53

**Examination requirements:** 240 hp

**Research subject:** Automatic Control (TEFRTF00)

**Admission date:** 2018-08-15

**Year/semester for planned half-time seminar/lic exam :** 2021/VT

**Year/term for planned PhD-exam:** 2023/VT

**Funding of the position as doctoral student:**

0-1.5 years: ELLIIT.

1.5-: ADMORPH EU-project.

**Collaboration agreement (if one exists):**

consortium agreement in ADMORPH EU-project

**Supervision:**

- Individual supervision

**Mutual ethical guidelines are approved:**

**Resources:**

Work place, desk and office

Computer

**Career guidance:**

**Risk assessment:** No

**Possible risk assessment, project:**

**Possible risk assessment, physical:**

**Possible risk assessment, ethical:**

**Midway review :**

**Percent of exam requirement finished :** 180 av 240 hp , 75 %

**Teaching/admin/other (portion in relation to full-time):** 20 %

**Activity:** 80 %

**Activity postgraduate studies and departmental duties/assignments (percent of full time):**

Term	Postgrad studies		Departmental duties / assignments	
	Planned	Actual	Planned	Actual
HT 2018	60%	60%	15%	15%
VT 2019	80%	80%	20%	20%
HT 2019	80%	80%	20%	20%
VT 2020	80%	80%	20%	20%
HT 2020	80%	80%	20%	20%
VT 2021	80%	80%	20%	20%
HT 2021	80%	80%	20%	20%
VT 2022	80%	80%	20%	20%
HT 2022	80%	80%	20%	20%
VT 2023	80%		20%	
HT 2023	20%		5%	
VT 2024				
In total:		3.50 year 80.00 %		0.88 year 20.00 %

**Remaining time for postgraduate support:****Departmental duties:**

- HT18: teaching assistant in Reglerteknik AK course  
teaching assistant in Project in Automatic Control course  
lab assistant in Nonlinear control course  
lab assistant in Reglerteknik AK course  
help streamlining procedures for ordering course material (python script)  
representing the department at Kulturnatten 2018
- VT19: help improve basic control course (lab 3)  
help develop the canvas page for the Project in Automatic Control course
- HT19: teaching assistant in Project in Automatic Control course  
lab assistant in Multivariable control course  
starting up a collaboration with Lund Formula Student
- VT20: teaching assistant in Real-time systems course  
structured material for computer exercises (Real-time systems)
- HT20: teaching assistant in new course Automatic control, Advanced course  
lab development for Automatic control, Advanced course  
due to Covid-19, helped structure material, exercises and labs to fit current regulations
- VT21: teaching assistant in Real-time systems course
- HT21: teaching assistant in Automatic control, Advanced course  
lab development for Automatic control, Advanced course  
due to Covid-19, helped structure material, exercises and labs to fit current regulations
- VT22: teaching assistant in Real-time systems course
- HT22: lab assistant in Automatic control, Advanced course

**Assignments within student organisations / student representation:****Teacher training:**

- Introduction to Teaching and Learning in Higher Education (5hp)

**Conference:**

- ECRTS 2018
- ELLIIT workshop 2018 (Poster)
- CPS-week Fog-IoT 2019 (Oral)
- ELLIIT workshop 2019 (Poster)
- CDC 2019 (Oral)
- CPS-week Fog-IoT 2020 (Oral, online)
- ECRTS 2021 (Oral, online)
- RTAS 2022 (Oral, online)
- ELLIIT workshop 2022
- CDC 2022 (Oral)

**International activities :**

ADMORPH project meetings.  
Conferences.  
HI20T workshops.

**Course requirements:** 90 hp

**Mandatory courses or other activities eligible for credits:**

**Completed courses and other credit-awarding components:**

*Credited courses (attended prior to admission)*

Name: Algoritmer, datastrukturer och komplexitet - EDAF05

Date of completion: 2017-06-04 Credits: 5

Registered in LADOK: No

**Total credited courses:** 5 hp

*Courses and other credit-awarding components within the third-cycle programme*

Name: Introduction to Neural Networks

Date of completion: 2019-02-21 Credits: 7.5

Registered in LADOK: Yes

Name: Convex Optimization

Date of completion: 2019-04-01 Credits: 7.5

Registered in LADOK: Yes

Name: Reinforcement learning

Date of completion: 2019-05-25 Credits: 5

Registered in LADOK: Yes

Name: Network dynamics

Date of completion: 2019-10-10 Credits: 7.5

Registered in LADOK: Yes

Name: Julia for scientific programming

Date of completion: 2019-10-11 Credits: 5

Registered in LADOK: Yes

Name: Introduction to teaching and learning in higher education

Date of completion: 2019-07-01 Credits: 5

Registered in LADOK: Yes

Name: Programming languages and concepts

Date of completion: 2020-06-04 Credits: 7.5

Registered in LADOK: Yes

Name: Control system synthesis

Date of completion: 2020-12-07 Credits: 7.5

Registered in LADOK: Yes

Name: Hands-on machine learning

Date of completion: 2020-06-07 Credits: 4

Registered in LADOK: Yes

Name: Introduction to Cryptography

Date of completion: Credits: 3

Registered in LADOK: No

Name: The C-programming Language

Date of completion: 2021-06-06 Credits: 7.5

Registered in LADOK: Yes

Name: Written English for Scholarly Publication

Date of completion: 2022-02-17 Credits: 5

Registered in LADOK: Yes

Name: Realtidsoperativsystem

Date of completion: 2022-03-11 Credits: 6

Registered in LADOK: Yes

Name: Physical Modelling

Date of completion: 2022-06-20 Credits: 5

Registered in LADOK: Yes

Name: The Rust Programming Language

Date of completion:

Credits: 5

Registered in LADOK: No

**Total, within the third-cycle programme: 88 hp****Total, all completed courses and credit-awarding components: 93 hp****Remaining, courses and other credit-awarding components: 0 hp****Planned courses:**

- Short-term plan:

The Rust Programming Language

- Long-term plan:

- Under consideration:

**Thesis requirements: 150 hp****Type of thesis:** Collection of articles**Thesis language:** English**Overview of the planned thesis work:**

Real-time embedded control systems.

(Fault tolerant analysis and design of real-time embedded control systems.)

**Evaluation and planning***Evaluation and planning of research (sub-projects of the thesis work)*Sub-project/manuscript 1

Title: Stability and Performance Analysis of Control Systems Subject to Bursts of Deadline Misses

Participants/authors: Nils Vreman, Martina Maggio, Anton Cervin

Data collection: 90 %

Analyses: 60 %

Writing: 30 %

Manuscript submitted: No

Manuscript accepted: Yes

Sub-project completed: Yes

Planning:

Content: The paper analyses general linear time-invariant plants controlled by digital linear time-invariant controllers, subject to deadline misses in the process executing the controller. The analysis comprises both stability and performance, as well as the different deadline handling strategies (Kill and Skip-Next) and hold strategies (Zero and Hold).

Plan: Manuscript accepted to ECRTS 2021. Awarded "Best Paper".

Sub-project/manuscript 2

Title: Stability of Linear Control Systems under Extended Weakly-Hard Constraints

Participants/authors: Nils Vreman, Paolo Pazzaglia, Jie Wang, Victor Magron, Martina Maggio

Data collection: 60 %

Analyses: 40 %

Writing: 40 %

Manuscript submitted: No

Manuscript accepted: Yes

Sub-project completed: Yes

Planning:

Content: The paper analyses digital control systems subject to a specific class of constraints on how the task governing the controller is allowed to fail (denoted weakly-hard constraints). The paper analyses the control system stability of this class of problem and presents a stability hierarchy given the "hardness" to satisfy different types of constraints.

Plan: Manuscript accepted to L-CSS + CDC 2022. To be presented in December.

Sub-project/manuscript 3

Title: Digital Twins for security and robustness for industrial control systems

Participants/authors: William Tärneberg, Fatemeh Akbarian, Per Skarin, Maria Kihl, Christian

Gehrmann, Nils Vreman

Data collection: %

Analyses: 20 %

Writing: 10 %

Manuscript submitted: No

Manuscript accepted: No

Sub-project completed: No

Planning:

Content: The letter paper plans to pose the problem of how to incorporate Digital Twins in the usage of networked industrial control systems. Main focus is the potential and potential problems of such a systems when it comes to computer security/integrity and control system timing guarantees.

Plan: Currently on hold.

#### Sub-project/manuscript 4

Title: Deadline-Miss-Adaptive Controller Implementation for Real-Time Control Systems

Participants/authors: Nils Vreman, Claudio Mandrioli, Anton Cervin

Data collection: 35 %                      Analyses: 35 %                      Writing: 35 %

Manuscript submitted: No                      Manuscript accepted: Yes

Sub-project completed: Yes

Planning:

Content: The paper includes a novel approach of an online controller adaptation strategy. Given a discrete control system, the strategy adapts the dynamic part of the controller to adjust for missed executions of the control task. No new controller have to be designed and no plant information is required. The proposed adaptation method is evaluated using a stochastic framework based on jump linear- and Markov-system theory.

Plan: Manuscript accepted to RTAS 2022.

#### Sub-project/manuscript 5

Title: WeaklyHard.jl: Scalable Analysis of Weakly-Hard Constraints

Participants/authors: Nils Vreman, Richard Pates, Martina Maggio

Data collection: 100 %                      Analyses: 80 %                      Writing: 50 %

Manuscript submitted: No                      Manuscript accepted: Yes

Sub-project completed: Yes

Planning:

Content: The paper contribution is twofold: (i) it provides theoretical results relating previously neglected weakly-hard constraints and (ii) it provides a toolbox for analysing weakly-hard constraints represented by automata.

Plan: Manuscript accepted to RTAS 2022.

#### Sub-project/manuscript 6

Title: Randomization as Mitigation of Directed Timing Inference Based Attacks on Time-Triggered Real-Time Systems with Task Replication

Participants/authors: Kristin Krueger, Nils Vreman, Richard Pates, Martina Maggio, Marcus Völp, Gerhard Fohler

Data collection: 25 %                      Analyses: 25 %                      Writing: 10 %

Manuscript submitted: No                      Manuscript accepted: Yes

Sub-project completed: Yes

Planning:

Content: The paper is a journal extension of our CDC 2019 paper in connection to the work done by Krueger, Völp, and Fohler.

Manuscript accepted in LITES.

#### Sub-project/manuscript 7

Title: Multilayer distributed control over 5G networks: Challenges and security threats

Participants/authors: Nils Vreman, Martina Maggio

Data collection: 50 %                      Analyses: 50 %                      Writing: 20 %

Manuscript submitted: No                      Manuscript accepted: Yes

Sub-project completed: Yes

Planning:

Content: The workshop paper discusses the security threats present in different levels of the 5G edge architecture (Local, Proximal, and Global level). The paper suggests some future research directions and discusses the possibilities and problems with the different levels.

#### Sub-project/manuscript 8

Title: Minimizing Side-Channel Attack Vulnerability Via Schedule Randomization

Participants/authors: Nils Vreman, Richard Pates, Kristin Krueger, Gerhard Fohler, Martina Maggio

Data collection: 100 %                      Analyses: 75 %                      Writing: 20 %

Manuscript submitted: No                      Manuscript accepted: Yes

Sub-project completed: Yes

Planning:

Content: The paper proposes a novel, optimal, mitigation strategy for side-channel attacks in real-time embedded control systems. The paper proves a tight upper bound on the entropy (randomness) possible in a fixed-priority schedule, with hard constraints. It also proves the minimum cardinality set needed to achieve such a bound.

#### Sub-project/manuscript 9

Title: Evaluation of burst failure robustness of control systems in the fog

Participants/authors: Nils Vreman, Claudio Mandrioli

Data collection: 60 %

Analyses: 60 %

Writing: 30 %

Manuscript submitted: No

Manuscript accepted: Yes

Sub-project completed: Yes

Planning:

Content: The workshop paper evaluates stability of a networked control system if bursts of communication faults were to appear in different parts of the network. Despite the small test, conclusions can be drawn regarding where the communication problems affect the system maximally.

#### Sub-project/manuscript 10

Title: Trusted Execution of Periodic Tasks for Embedded Systems

Participants/authors: Martin Gunnarsson, Nils Vreman, Martina Maggio

Data collection: 50 %

Analyses: 40 %

Writing: 50 %

Manuscript submitted: Yes

Manuscript accepted: No

Sub-project completed: No

Planning:

Content: The paper analyses the resilience and robustness of a real-time embedded control system under attack. To mitigate attack vectors in the first place, the paper utilises a fairly recent technology (in embedded devices) called a Trusted Execution Environment (TEE) to hide the control data and algorithm from a potential attacker. The control performance and real-time overhead is analysed in different scenarios.

Plan: Submitted to IFAC 2023. Currently awaiting reviews.

#### Sub-project/manuscript 11

Title: Stochastic Stability Analysis of Control Systems Subject to Communication and Computation

Faults

Participants/authors: Nils Vreman, Martina Maggio

Data collection: 100 %

Analyses: 100 %

Writing: 80 %

Manuscript submitted: Yes

Manuscript accepted: No

Sub-project completed: No

Planning:

Content: The paper analyses control system stability when messages are lost on the network and the control computation can overrun its deadline. Mainly, the aim of the paper is to shed some light on the common misconceptions that lost messages on the network and deadline overruns in the hardware are equivalent events.

Plan: Submitted to RTAS 2023. Currently awaiting reviews

#### Sub-project/manuscript 12

Title: Robust Control Design of Weakly-Hard Control Systems using Automatic Differentiation

Participants/authors: Nils Vreman, Max Nyberg Carlsson, Martina Maggio, Anton Cervin

Data collection: 100 %

Analyses: 100 %

Writing: 100 %

Manuscript submitted: No

Manuscript accepted: No

Sub-project completed: No

Planning:

Content: The paper proposes a novel approach to synthesising controllers that optimise quality of control (QoC) when the controller is subject to deadline overruns adhering to the weakly-hard constraints. We analyse the worst-case sequence and design a controller for this case.

Plan: The analysis exist, but not paper has begun to be written. The plan is also to involve Max Nyberg Carlsson as first author and continue the work together. Submission details will be decided later.

#### Sub-project/manuscript 13

Title: Timing-Robust Control over the Cloud Using On-Line Parametric Optimization

Participants/authors: Max Nyberg Carlsson, Nils Vreman, Anton Cervin

Data collection: %

Analyses: 5 %

Writing: 20 %

Manuscript submitted: Yes

Manuscript accepted: No

Sub-project completed: No

Planning:

Content: The paper proposes a way to perform parametric optimization to adapt a controller executing in the cloud to timing uncertainties and issues.

Plan: Submitted to IFAC 2023. Currently awaiting reviews

**Completed thesis work:** 90 hp

**Remaining thesis work:** 60 hp

**Activities (carried out or planned) to achieve the learning outcomes stated in the higher education ordinance**

Knowledge and understanding, for the **degree of doctor** the third-cycle student shall

*- demonstrate broad knowledge and systematic understanding of the research field as well as advanced and up-to-date specialised knowledge in a limited area of this field*

Knowledge and understanding, for the **degree of licentiate**, the third-cycle student shall

*- demonstrate knowledge and understanding in the field of research including current specialist knowledge in a limited area of this field*

**Interpretation of the learning outcome**

Fulfilled when the student through courses, teaching, presentations, literature review, and other activities has gained broad knowledge in automatic control and related areas that goes beyond the level of a Master student in the subject; as well as a significant specialized knowledge in the student's specific research field.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Multiple courses finished within both my research topic, as well as core control.
- \* Teaching courses given at the department.
- \* Presented research at local, national, and international venues.
- \* Published papers in peer-reviewed conferences and journals.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Courses within both my research topic, as well as core control.
- \* Teaching courses given at the department.
- \* Present research at local, national, and international venues.
- \* Publish papers in peer-reviewed conferences and journals.

Knowledge and understanding, for the **degree of doctor** the third-cycle student shall

*- demonstrate familiarity with research methodology in general and the methods of the specific field of research in particular*

Knowledge and understanding, for the **degree of licentiate**, the third-cycle student shall

*- demonstrate specialised knowledge of research methodology in general and the methods of the specific field of research in particular*

**Interpretation of the learning outcome**

Fulfilled when the student through various activities has become familiar with typical research methodologies in general and in engineering subjects or applied mathematics in particular. A learning outcome is to know the difference between engineering work and research in engineering fields.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Taken courses in scholarly writing.
- \* Published papers in peer-reviewed conferences and journals.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Take courses in scholarly writing.
- \* Publish papers in peer-reviewed conferences and journals.

Competence and skills, for the **degree of doctor** the third-cycle student shall

*- demonstrate the capacity for scholarly analysis and synthesis as well as to review and assess new and complex phenomena, issues and situations autonomously and critically*

**Interpretation of the learning outcome**

Fulfilled when the student through research activities has shown the ability to, e.g., independently analyze a given scientific problem, derive theoretical arguments, theorems, algorithms, and write computer programs for simulation and verification. The student should also be able to assess the quality and verify the correctness of new contributions to the area.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Read and reviewed the research papers and theses of others.
- \* Participated in meetings with the supervisors, research group meetings, and project meetings.
- \* Participated in local, national, and international conferences and workshops.
- \* Done review work for conferences and journals.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Read and review the research papers and theses of others.
- \* Participate in meetings with the supervisors, research group meetings, and project meetings.
- \* Participate in local, national, and international conferences and workshops.
- \* Do review work for conferences and journals.
- \* Write thesis.

Competence and skills, for the **degree of doctor** the third-cycle student shall

*- demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to plan and use appropriate methods to undertake research and other qualified tasks within predetermined time frames and to review and evaluate such work*

Competence and skills, for the **degree of licentiate**, the third-cycle student shall

*- demonstrate the ability to identify and formulate issues with scholarly precision critically, autonomously and creatively, and to plan and use appropriate methods to undertake a limited piece of research and other qualified tasks within predetermined time frames in order to contribute to the formation of knowledge as well as to evaluate this work*

**Interpretation of the learning outcome**

Fulfilled when the student through research activities has shown the ability to independently formulate new research questions and suggest new research directions, from which novel research is conducted.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Identified unsolved questions and knowledge gaps in my field.
- \* Published novel research in peer-reviewed conferences and journals.
- \* Suggested a MSc project.
- \* Written papers with hard submission deadlines.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Identify more unsolved questions and knowledge gaps in my field.
- \* Publish novel research in peer-reviewed conferences and journals.
- \* Supervise MSc project.
- \* Write papers with hard submission deadlines.

Competence and skills, for the **degree of doctor** the third-cycle student shall

*- demonstrate through a dissertation the ability to make a significant contribution to the formation of knowledge through his or her own research*

**Interpretation of the learning outcome**

Fulfilled when the student has written a thesis that is approved on a dissertation.



**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Published papers in peer-reviewed conferences and journals.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Write a thesis.

Competence and skills, for the **degree of doctor** the third-cycle student shall

*- demonstrate the ability in both national and international contexts to present and discuss research and research findings authoritatively in speech and writing and in dialogue with the academic community and society in general*

Competence and skills, for the **degree of licentiate**, the third-cycle student shall

*- demonstrate the ability in both national and international contexts to present and discuss research and research findings in speech and writing and in dialogue with the academic community and society in general*

**Interpretation of the learning outcome**

Fulfilled when the student has published papers, attended conferences or workshops/summer schools, and made successful research presentations as well as some activity targeted for the general public.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Written and published peer-reviewed conference and journal papers.
- \* Presented research at local, national, and international venues.
- \* Visited other research groups at other universities.
- \* Taken courses in teaching for higher education and writing scholarly publications.
- \* Participated in Kulturnatten.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Write and publish peer-reviewed conference and journal papers.
- \* Present research at local, national, and international venues.
- \* Visit other research groups at other universities.
- \* Write popular science description of my work.

Competence and skills, for the **degree of doctor** the third-cycle student shall

*- demonstrate the ability to identify the need for further knowledge*

**Interpretation of the learning outcome**

Fulfilled when the student has shown the ability through her research work to identify the need for further knowledge for the community.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Formulated novel research questions.
- \* Suggested research directions based on knowledge gaps in the literature.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Formulate novel research questions.
- \* Suggest research directions based on knowledge gaps in the literature.

Competence and skills, for the **degree of doctor** the third-cycle student shall

*- demonstrate the capacity to contribute to social development and support the learning of others both through research and education and in some other qualified professional capacity*

Competence and skills, for the **degree of licentiate**, the third-cycle student shall

*- demonstrate the skills required to participate autonomously in research and development work and to work autonomously in some other qualified capacity.*

**Interpretation of the learning outcome**

Fulfilled when the student in his or her research argues around its possible contribution to social development; or through teaching, scientific presentations and networking, interaction with industry and society, supports the learning of others.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Taught undergraduate courses.
- \* Developed new course material.
- \* Taken the pedagogical course "Introduction to teaching and learning in higher education"
- \* Developed computer program that can aid others in learning real-time systems.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Teach undergraduate courses.
- \* Develop new course material.
- \* Develop material (tools) that can aid others in learning real-time systems.

Judgement and approach, for the **degree of doctor** the third-cycle student shall

*- demonstrate intellectual autonomy and disciplinary rectitude as well as the ability to make assessments of research ethics*

udgement and approach, for the **degree of licentiate** the third-cycle student shall

*- demonstrate the ability to make assessments of ethical aspects of his or her own research*

**Interpretation of the learning outcome**

Fulfilled when the student has taken a course in Ethics, follows the ethical guidelines and rules in her work, and shown intellectual autonomy in her research conduct.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Discussed and reflected on research ethics when writing scientific papers.
- \* Collected data with respect to ethical guidelines and rules.
- \* Written papers as first author.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Discuss and reflect on research ethics when writing scientific papers.
- \* Collect data with respect to ethical guidelines and rules.
- \* Defend my doctoral thesis.

Judgement and approach, for the **degree of doctor** the third-cycle student shall

*- demonstrate specialised insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used*

Judgement and approach, for the **degree of licentiate** the third-cycle student shall

*- demonstrate insight into the possibilities and limitations of research, its role in society and the responsibility of the individual for how it is used*

**Interpretation of the learning outcome**

Fulfilled when the student in her research publications, thesis and popular summary, or through other activities, has addressed such more general questions as the possibilities and limitations of research, and its role in society.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Included analysis of possibilities and limitations of our results in corresponding research paper.
- \* Taken part in discussions on research's part in society.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Include analysis of possibilities and limitations of our results in corresponding

research paper.

Judgement and approach, for the **degree of licentiate** the third-cycle student shall

*- demonstrate the ability to identify the personal need for further knowledge and take responsibility for his or her ongoing learning*

**Interpretation of the learning outcome**

Fulfilled when the student shows ability to identify her personal need for further knowledge and takes responsibility for and plans her study activities.

**Completed activities contribution to the learning outcome**

Completed Activities:

- \* Identified, read up on, and researched an open research question.
- \* Initiated study circle in topic I'm no expert in.
- \* Participated in study circles in topics I'm no expert in.

**Planned activities contribution to the learning outcome**

Planned Activities:

- \* Participate in study circle in topic I'm no expert in
- \* Identify, read up on, and research an open research question.

Signatures

Lund 2023-01-19

.....  
Nils Vreman  
PhD Student

.....  
Martina Maggio  
Main supervisor

.....  
Anton Cervin  
Assistant supervisor

.....  
Karl-Erik Årzén  
Assistant supervisor

.....  
Pontus Giselsson  
Representative of the department

.....  
Pontus Giselsson  
Director of studies

.....  
Anders Rantzer  
Head of Department