The Faculty of Engineering and Science
The Study Board of Civil Engineering

AALBORG UNIVERSITY
DENMARK

Curriculum for

The Master's Programme

in Water and Environmental Engineering

Aalborg University

September 2017

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dekan

Campus: Aalborg

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Preface:
Pursuant to Act 261 of March 18, 2015 on Universities (the University Act) with subsequent changes, the following curriculum for the Master's program in Water and Environmental Engineering is stipulated. The program also follows the Joint Programme Regulations and the Examination Policies and Procedures for The Technical Faculty of IT and Design, The Faculty of Engineering and Science, and The Faculty of Medicine.

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Chapter 1: Legal Basis of the Curriculum, etc.

1.1 Basis in ministerial orders
The Master's program in Water and Environmental Engineering is organised in accordance with the Ministry of Higher Education and Science's Order no. 1061 of June 30, 2016 on Bachelor's and Master's Programmes at Universities (the Ministerial Order of the Study Programmes) and Ministerial Order no. 1062 of June 30, 2016 on University Examinations (the Examination Order). Further reference is made to Ministerial Order no. 258 of March 18, 2015 (the Admission Order) and Ministerial Order no. 114 of February 3, 2015 (the Grading Scale Order) with subsequent changes.

1.2 Faculty affiliation
The Master's programme falls under the Faculty of Engineering and Science.

1.3 Board of Studies affiliation
The Master's programme falls under the Board of Studies for Civil Engineering in the School of Engineering and Science. The programme belongs to the Institutions of Higher Education in Engineering's nationwide External Examiner Corps in the field of Civil Engineering.

1.4. External Evaluation Corps
The programme falls under the external evaluator corps: ingeniøruddannelernes censorkorps - bygning

Chapter 2: Admission, Degree Designation, Programme Duration and Competence Profile

2.1 Admission
Applicants with a legal claim to admission:

- Bachelor of Science in Civil Engineering with specialisation in Water and Environment, Aalborg University

Applicants without legal claim to admission:

- Bachelor of Science in Indoor Environmental and Energy Engineering, Aalborg University
- Bachelor of Science in Environmental Engineering, Aalborg University
- Bachelor of Science in Environmental Science, Aalborg University
- Bachelor of Science in Environmental Engineering, Technical University of Denmark
- Bachelor of Science in Civil Engineering with specialisation in Environmental Engineering, VIA University College
- Bachelor of Science in Supply Engineering in Water, Wastewater and District Heating, VIA University College
- Bachelor of Science in Engineering (Environmental Engineering), Aarhus University – School of Engineering

Applicants without legal claim to admission:
Students with another Bachelor's degree, upon application to the Board of Studies, will be admitted after a specific academic assessment if the applicant is deemed to have comparable educational prerequisites. The University can stipulate requirements concerning conducting additional exams prior to the start of study.

For further information on admission, see www.en.aau.dk.

All applicants must, as a minimum, document English language qualifications comparable to an "English B level" in the Danish upper secondary school (gymnasium) (the Admission Order).

2.2 Degree designation in Danish and English
The Master's program entitles the graduate to the designation civilingeniør, cand.polyt. (candidatus/candidata polytechnices) i vand og miljø. The English designation is: Master of Science (MSc) in Engineering (Water and Environmental Engineering).

2.3 The programme's specification in ECTS credits
The Master's programme is a 2-year, research-based, full-time study programme. The programme is set to 120 ECTS credits.

2.4 Competence profile on the diploma
The following competence profile will appear on the diploma:

> **A Candidatus graduate has the following competency profile:**
> A Candidatus graduate has competencies that have been acquired via a course of study that has taken place in a research environment.
>
> A Candidatus graduate is qualified for employment on the labour market on the basis of his or her academic discipline as well as for further research (PhD programmes). A Candidatus graduate has, compared to a Bachelor, developed his or her academic knowledge and independence so as to be able to apply scientific theory and method on an independent basis within both an academic and a professional context.

2.5 Competence profile of the programme:

<u>The graduate of the Master's programme:</u>

Knowledge	• Knowledge on technology and applicability of in-situ physical and biological methods for remediation of contaminated soil and groundwater zones at polluted soil sites. • Understanding of the physics of the coastal zone and estuaries including currents, waves, sediment transport. • Basic understanding of the ecological conditions in natural waters including the effect of various types of pollution on flora and fauna. • Shall have knowledge on how numerical methods and experiments methods complement each other and how to use experimental data to improve numerical models. • Shall have knowledge on how urban waste and storm water runoff interacts with our cities and its surrounding environment. • Must have knowledge on effects and consequences of urban flooding.
Skills	• To analyze, synthesize and evaluate contaminant spill situations in regard to risk for area use and soil and groundwater resources around a polluted soil site. • To apply selected methods to measure water transport parameters, solute transport parameters, gas transport parameters, and/or biodegradation coefficients in soil and groundwater. • Explain the environmental impact of selected compounds on aquatic environments • Identify the hydrological, chemical and biological processes

	that are central for the analysis and evaluation of a coastal marine environment and evaluate toxicological effects on an aquatic ecosystem. • Use impact assessment methods. • Build and analyze numerical water quality models. • Plan and carry out the measurement program for field and laboratory measurements. • Analyze errors and uncertainties in the measurement and modeling in natural or environmental engineering systems. • Be able to evaluate the consequences of climate change for urban drainage systems. • Combine knowledge on hydrodynamic performance of the storm drainage system with knowledge on the consequences in the receiving waters. • Must be able to disseminate the results obtained from the project work in a project report. • Must be able to work jointly with the project problem field project and make a joint presentation of the project work results.
Competences	• To handle soil and groundwater pollution in relation to the groundwater resource, indoor climate, areal use. • To structure and produce technical documentation of complex problems, methods and results. • To communicate problems, findings and solutions graphical as well as oral to the relevant target audience. • To perform water quality assessment studies for different types of impacts in natural waters. • Be able to combine experimental data and numerical methods to develop better models within the area of water & environment. • Be able to plan the drainage structure for an entire city with respect to flooding, receiving water quality and climate change.

Chapter 3: Content and Organization of the Programme

The programme is structured in modules and organized as a problem-based study. A module is a programme element or a group of programme elements, which aims to give students a set of professional skills within a fixed time frame specified in ECTS credits, and concluding with one or more examinations within specific exam periods. Examinations are defined in the curriculum.

The programme is based on a combination of academic, problem-oriented and interdisciplinary approaches and organized based on the following work and evaluation methods that combine skills and reflection:

- lectures
- classroom instruction
- project work
- workshops
- study groups
- exercises (individually and in groups)
- laboratory tests

- measurements and testing in the field
- teacher feedback
- reflection
- portfolio work
- independent study

The modules are evaluated either through written or oral exams as stated in the description of the modules.

For individual written exams the study board selects among the following possibilities:

- Written exam based on handed out exercises
- Multiple choice
- Ongoing evaluation of written assignments

For individual oral exams the study board selects among the following possibilities:

- Oral exam with or without preparation
- Oral exam based on project report (individually graded through group exam)
- Oral exam based on presentation seminar
- Portfolio based oral exam

If the number of students following a module is small and/or if the number of students having to attend a re-exam is small the study board can decide that an exam is conducted either as an oral or written individual exam for economic reasons. In the first case decision must be notified before the start of the teaching activity, in the latter case the students must be notified when the examination date is decided.

1st to 4th semesters of the programme are taught in English and projects are to be written in English. However, the programme can be taught in Danish if no international students are enrolled.

3.1 Overview of the programme

All modules are assessed through individual grading according to the 7-point scale *or* Pass/Fail. All modules are assessed by external examination (external grading) or internal examination (internal grading or by assessment by the supervisor only).

Of a total of 120 ECTS, 95-110 ECTS are assessed by the 7-point scale and 45-75 ECTS are assessed by external examination.

Semester		Module	ECTS	Assessment	Exam
1st		Soil and Groundwater Pollution[3]	15	7-point scale	Internal
		Hydrogeology and Groundwater Modelling	5	Pass/no-pass	Internal
		Environmental Soil Science and Geostatistics	5	Pass/no-pass	Internal
		Experimental Hydrology	5	7-point scale	Internal
2nd	A	Marine and Freshwater Pollution[1,3] (optional for international students)	15	7-point scale	External
	B	Wastewater Treatment Systems[1,3] (optional for international students)	15	7-point scale	External
		Hydrodynamics and Time Series Analysis of Environmental Flows	5	7-point scale	Internal
		Marine Pollution	5	7-point scale	Internal
	C	Limnology[2] (optional for international students)	5	7-point scale	Internal
	D	Fundamental Wastewater Treatment[2]	5	7-point scale	Internal
3rd	A	Numerical Modelling and Experimental Methods[3]	15	7-point scale	Internal
	B	Advanced Urban Drainage[3]	15	7-point scale	Internal
	A/B	Advanced Hydrodynamic Modelling (CFD) and Visualisation.	5	Pass/no-pass	Internal
		Urban Hydroinformatics	5	Pass/no-pass	Internal
		Measurement Technology,Data Acquisition, Test and Validation	5	Pass/no-pass	Internal
	C	Study at another university	15-30	See below	-
	D	Academic Internship	30	7-point scale	Internal
3rd - 4th		Long Master's Thesis	45/50/ 60	7-point scale	External
4th		Master's Thesis	30	7-point scale	External
Total			120		

1) International students that attend the master in Water and Environmental Engineering can on 2nd semester choose between either project option A or B. All others students should follow option A
2) International students that attend the master in Water and Environmental Engineering and have chosen project option B (Wastewater Treatment Systems) should attend course option D (Fundamental Wastewater Treatment). If project option A is chosen – course option C (Limnology) should be attended. All other students should follow course option C.
3) Students not familiar with Problem-based Learning at Aalborg University must attend the course "Problem-based Learning (PBL) and Student Responsibility" as an integrated part of the project module on 1st, 2nd or 3rd semester, at the first semester studying at Aalborg University.

On the 3rd semester, the students must choose between project option A and B and follow the three course modules. Option B is minded on international students that don't have an urban drainage background. If option C is chosen on the 3rd semester - the study board must approve on the contents before the study is commenced. The amount of ECTS followed at the other university must be between 15-30 ECTS such that the size of the master's thesis is the remainder of the ECTS up to 60 ECTS for both the 3th and the 4th semester.

If the longer master's thesis option is selected, the master's thesis is either 45, 50 or 60 ECTS and additional course modules on the third semester must be selected to reach 60 ECTS for the 3rd and 4th semester in total.

The students are given options in the project modules as they can select among different projects within the same general theme. Moreover, the master's thesis on the 4th semester can be selected freely within the field of water and environment.

The study board of civil engineering can decide, that the contents of a course module on a semester is taught in the project module in the same semester, by increasing the ECTS extend of the project module by the same number of ECTS. The decision is taken regarding to capacity and/or economy.

3.2 Water and Environmental Engineering 1st Semester

3.2.1 Problem Based Learning and Project Management
Problembaseret læring og projektledelse

Objective
The objective is to make newly started Master students coming from institutions other than AAU prepared to enter the problem based learning environment at AAU and manage study projects in close collaboration with peers.

Type of instruction
Three half day workshops centered around the individual student working with an individual challenge or curiosity in relation to using a PBL approach. Peer learning is also a hallmark, since the students will discuss and reflect their individual challenges/curiosities in a peer learning group.

Learning outcomes
After completion of the course the student should be able to

Day 1:
- describe and discuss the Aalborg PBL model based on the three key words: group work, project work, problem orientation
- identify an initial individual challenge when using a PBL approach

Day2:
- develop and practice peer feedback skills
- practice collaborative learning in a group
- design a plan of action to deal with an initial individual PBL challenge or curiosity

Day 3:
- practice presentation skills
- practice critical skills when giving feedback to peers
- reflect on own and peer skills in relation to PBL practice

Exam format
Internal assessment during the course/class participation according to the rules in the Examination Policies and Procedures of Faculty of Engineering and Science, Aalborg University. In this case the assessment is primarily based on the oral performance during the course, which means that the student has to be active during the course time and participate in discussions. The course is an integrated part of the project for those not acquainted to the Aalborg PBL model, and is a precondition for participation in the project examination. In this way there will be no diploma for the course and it will not be visible on the academic transcripts.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.2.2 Soil and Groundwater Pollution (P)
Jord og grundvandsforurening

Prerequisites
Students holding a bachelor degree from another university than Aalborg University must pass the course: Problem Based Learning and Project Management at Aalborg University, prior to sitting the exam.

The module adds to the knowledge obtained in e.g. the courses Experimental Hydrology, Environmental Soil Science and Geostatistics.

Objective
The main aim of the project is to qualify the student to understand, measure and model transport and degradation of compounds and contaminants in the water-unsaturated (vadose) soil zone and the water-saturated groundwater zone at and around an urban contaminated soil site, and to apply this in evaluation and design of risk assessment and remediation regarding area use, soil and water resources.

Knowledge
- Knowledge on technology and applicability of in-situ physical and biological methods for remediation of contaminated soil and groundwater zones at polluted soil sites.

Skills
- To analyse, synthesize and evaluate contaminant spill situations in regard to risk for area use and soil and groundwater resources around a polluted soil site.
- To apply selected methods to measure water transport parameters, solute transport parameters, gas transport parameters, and/or biodegradation coefficients in soil and groundwater.
- To model transport of fluids (water and/or air) and transport and degradation of contaminants in soil and groundwater, using own models for one dimensional problems and ready-available software for two or three dimensional problems.

Competences
- To handle soil and groundwater pollution in relation to the groundwater resource, indoor climate, areal use.
- To structure and produce technical documentation of complex problems, methods and results.
- To communicate problems, findings and solutions graphical as well as oral to the relevant target audience.
- Must be able to communicate the results of the project work in a project report.
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work.

Type of instruction
Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format
Oral exam based on presentation seminar and project rapport.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.2.3 Experimental Hydrology (C)
Eksperimentel hydrologi

Objective
To qualify the student to understand and estimate hydro-geological parameters by in-situ and laboratory test and experiments in relation to a specific site and/or transport phenomenon. This includes the planning of a measuring programme based on suitable measuring methods and positions, setting up a time schedule and a data processing procedure.

Finally the opening project aims to give especially students without experiences in problem and project based learning hands-on experiences with this leaning method.

Knowledge
- On the groundwater system and its essential properties and parameters.
- On experimental methods for property and parameter estimation of the ground water zone.
- On uncertainty and limitations of the applied methods.

Skills
- To select, design and conduct suitable in-situ test for estimating saturated hydraulic properties.
- To select, design and conduct suitable laboratory test for estimating hydraulic saturated hydraulic properties.
- To analyse and evaluate test results and methods regarding suitability and reliability.
- To organise documentation and presentation of measured data.

Competences
- To describe, analyse, and evaluate a specific part of the groundwater system, regarding its composition and its properties through a planned investigation of the system.
- To structure and plan the project and the work in a group.
- To produce technical documentation of complex problems, methods and results in group cooperation.
- To communicate findings and solutions graphical as well as oral to the relevant target audience.

Type of instruction
Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format
Individual exam, written or oral based on presentation seminar and mini-project report. Exam format is decided on by start of semester.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.2.4 Environmental Soil Science and Geostatistics (C)
Jordfysik og geostatistik

Objective
To give the students fundamental knowledge of water and contaminant transport, sorption and degradation in soil, and the use of geostatistical methods in contaminated soil studies. The student should understand the links between the physical, chemical and biological processes in soil. The student should know the principles behind and how to apply relevant laboratory and field methods for measurement of water and solute transport in soil, know the principles behind and the applicability of relevant physical- and biological-based remediation methods for contaminated soil sites, and be able to calculate one-dimensional water and solute transport in the soil vadose zone (from soil surface to capillary water table).

Knowledge
- On fundamental soil physics.
- On soil texture and structure, physical and chemical phase distribution (solids, water, air), pore-size distribution, water retention, hydraulic conductivity, soil-water sorptivity, unsaturated zone water transport, gas diffusion and chemical transport, sorption and biodegradation.
- On the basic principle of 1D analytical and numerical water and contaminant transport modelling.
- On evaluating the uncertainty of measured data and model results.

Skills
- To measure soil hydraulic properties in the laboratory.
- To apply parameter models for water retention, hydraulic conductivity, gas diffusion, and chemical dispersion to measured data or as predictive tools.
- To program and apply analytical and simple numerical water and solute transport models to measured data or in risk assessment.
- To apply relevant geostatistical methods to measured data in the soil and groundwater zones.

Competences
- To perform preliminary risk assessment and evaluate the conditions for on-site or in-situ clean-up methods for contaminated soil sites.
- To structure and produce technical documentation of complex problems, methods and results.
- To communicate problems, findings and solutions graphical as well as oral to the relevant target audience.

Type of instruction
Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format
Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.2.5 Hydrogeology and Groundwater Modelling (C)

Hydrogeologi og grundvandsmodellering

Objective

To give the students fundamental knowledge of water and contaminant transport in the groundwater zone. Based on hydrological and hydrogeological data the student shall be able to set-up, calibrate and validate a groundwater model for an area of suitable size. Furthermore the student should obtain knowledge of model parameter and uncertainty estimation.

Knowledge

- On fundamental hydrogeology.
- On the basic principle of numerical groundwater modelling.
- On chemical transport, dispersion, sorption/retardation and degradation in the groundwater zone.
- On evaluating the uncertainty of the model results.

Skills

- To collect, analyse and visualise the various data that forms the basis for the conceptual model.
- To construct, calibrate and validate groundwater models.
- To simulate water and contaminate transport.
- To evaluate and quantify modelling uncertainty.

Competences

- To evaluate and handling hydrological data that forms the basis for groundwater modelling.
- To structure and produce technical documentation of complex problems, methods and results.
- To communicate problems, findings and solutions graphical as well as oral to the relevant target audience.

Type of instruction

Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format

Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria

As stated in the Joint Programme Regulations.

3.3 Water and Environmental Engineering 2nd Semester

3.3.1 Marine and Freshwater Pollution (Project option A)
Forurening af akvatiske systemer

Project option A – optional for international students – mandatory for all others

Prerequisites
The module adds to the knowledge obtained in Limnology, Hydrodynamics, Marine Pollution, Time Series Analysis.

Objective
The aim of the project is to qualify the student to plan and design engineering solutions to various types of pollution of both fresh and saline aquatic environments, coming from discharge of sewage from waste water plants, discharge of urban storm drainage, cooling water discharges from power plants, the establishment of dams, embankments, and other civil engineering works etc.

Knowledge
- Advanced understanding of the physics of freshwater recipients, the coastal zone and estuaries including currents, waves, sediment transport.
- Basic understanding of the ecological conditions in natural waters, including streams, rivers, lakes, estuaries and coastal waters. Understanding the effect of various types of pollution on flora and fauna in these areas.

Skills
- Identify the hydrological, chemical and biological processes that are central for the analysis and evaluation in the aquatic environment.
- Explain the environmental impact of selected compounds on aquatic environments.
- Evaluate toxicological effects on an aquatic ecosystem.
- Use impact assessment methods.
- Build and analyse numerical water quality models.
- Apply advanced hydrodynamic and water quality models.
- Evaluate methods for the analysis of changing impacts on aquatic environments.

Competences
- To plan and design structures for various types of discharges to freshwater recipients, the coastal zone and estuaries.
- To model numerically the importance of necessary treatment for obtain specified demands on the water quality in the system
- To be able to conduct experimental, empirical and/or theoretical investigations which are necessary for the solution of one or more identified problems.
- To perform water quality assessment studies for different types of impacts on different recipients.
- Must be able to communicate the results of the project work in a project report.
- Must be able to teamwork within the problem area and make a common presentation of the result of the project work.

Type of instruction
Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format
Oral exam based on presentation seminar and project rapport.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.3.2 Wastewater Treatment Systems *(Project option B)*
Spildevandsrensning

Project option B – optional for international students only

Prerequisites
The module adds to the knowledge obtained in Wastewater Treatment

Objective
The aim of the project is to qualify the student to design and operate urban wastewater treatment systems and to gain knowledge on the microbiological and chemical transformations processes that takes place in a wastewater treatment plant.

Knowledge
- Account for physical, microbial and chemical methods for separation and treatment of wastewater by activated sludge processes.
- Describe the different microbiological and chemical processes that participate in wastewater treatment.

Skills
- Apply methods for design and analysis of wastewater treatment plants.
- Dimension and run a treatment plant.

Competences
- Should be able to identify problems with existing systems and be able to solve these problems.
- Should be able to conduct experimental, empirical and/or theoretical investigations which are necessary for the solution of one or more identified problems.
- Must be able to communicate the results of the project work in a project report.
- Must be able to teamwork within the problem area and make a common presentation of the result of the project work.

Type of instruction
Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format
Oral exam based on presentation seminar and project rapport.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.3.3 Hydrodynamics and Time Series Analysis of Environmental Flows (C)
Hydrodynamik og tidsserieanalyse for miljøhydrauliske forhold

Prerequisites
The module adds to the knowledge obtained in Fundamental Hydraulics, Fundamental Statistics and Differential Equations.

Objective
The aim of the course is to give the student a fundamental knowledge of water flow in marine environments. Based on the gained knowledge the student shall be able to analyse time series of environmental data and set up numerical models for a given aquatic environment.

Knowledge
- On advanced hydrodynamics.
- On numerical modelling of turbulent flows.
- On modelling of transport and mixing.
- On environmental flow in coastal zones and estuaries.
- On basic time series analysis.

Skills
- To perform a systematic analysis of the physics in the coastal zone and estuaries.
- To perform non-stationary time simulations with advanced hydrodynamic models.
- To analyse time series for persistence and harmonic elements.
- To analyse geophysical flows in the ocean and coastal zone.

Competences
- To evaluate and handle data that forms the basis of hydrodynamic and water quality modelling.
- To structure and produce technical documentation of complex problems, methods and results.
- To communicate problems, findings and results graphically as well as oral to the relevant target audience.

Type of instruction
Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format
Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.3.4 Marine Pollution (C)
Forurening af marine områder

Objective
To provide fundamental insight into coastal marine waters including effects and prevention of natural and anthropogenic pollution.

Knowledge
- On marine ecosystems.
- On theory for physical, chemical and microbial processes in marine systems.
- On the most common types of marine pollution.

Skills
- To understand the exchange of matter between aquatic and terrestrial environments.
- To describe the marine ecosystem, light, salinity and temperature.
- To understand primary production, respiration and re-oxidation.
- To analyse microbial loops, food webs, turnover of C-N-S in aquatic environments.
- To analyse marine sediments.
- To distinguish pollution impacts on individuals, populations and communities.
- To evaluate man-made pollutants (xenobiotics), disease-causing microorganisms (pathogens) in marine waters.
- To assess recreational and bathing water quality and related fecal pollution source tracking.

Competences
- Work with and analyze nutrient cycling in coastal marine ecosystem.
- Describe important organic and inorganic pollutants and pollution effects in coastal marine waters.
- Evaluate methods to prevent and alleviate antropogenic pollution in coastal marine waters evaluate meth.

Type of instruction
Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format
Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.3.5 Limnology (course option c)
Limnologi

Course option C – optional for international students – mandatory for all others

Prerequisites
The module adds to the knowledge obtained in Fundamental Hydraulics, Biology, Chemistry and Physics.

Objective
To provide fundamental insight into freshwater ecology and freshwater ecosystems. The student will be introduced to physical, chemical and biological dynamics of natural freshwater ecosystems, and the effects of natural and anthropogenic pertubations on structure and function.

Knowledge
- Of key components of freshwater ecosystems.
- Of relevant theory for physical, chemical and biological processes in freshwater ecosystems.
- Of dominant anthropogenic types of pollution affecting freshwater ecosystems.

Skills
- Shall be able to differentiate between major types of streams, rivers and lakes.
- Shall be able to understand the exchange of matter between aquatic and terrestrial environments.
- Shall be able to explain lake and river ecosystem dependence on light, temperature, nutrients and organic matter.
- Shall be able to understand primary production, respiration and re-oxidation in freshwater ecosystems.
- Shall be able to determine the significance of hydraulic conditions on chemical and biological dynamics in lakes and rivers.
- Shall be able to analyse oxygen dynamics in freshwater environments.
- Shall be able to analyse impacts of pollution on biotic communities.
- Shall be able to use existing pollution indicators for running waters and lakes to assess the pollution of a given location.
- Shall be able to account for current river and lake restoration methods.

Competences
- Work with and analyze biological communities in relation to nutrient dynamics and organic matter cycling in lake and river ecosystems.
- Describe important organic and inorganic pollutants and pollution effects in freshwater ecosystems.
- Evaluate methods to prevent and alleviate anthropogenic perturbations in freshwater ecosystems using existing technologies.

Type of instruction
Lectures supplemented with project work, workshops, presentation seminars, lab tests, and field work.

Exam format
Individual oral or written exam. Exam format is decided at the start of each semester.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.3.6 Fundamental Wastewater Treatment (course option D)
Grundlæggende spildevandsrensning

NOTE that this course is conducted together with the 6th semester bachelor in Civil Engineering (with specialisation in Water and Environment) (AAU). The intended learning outcome is increased compared to the bachelor level.

Course option D – optional for international students only

Prerequisites
The module adds to the knowledge obtained in Fundamental Chemistry, Biology and Hydraulics.

Objective
To gain knowledge on the composition and characterization of wastewater and to the processes that are used to treat urban wastewater.

Knowledge
- Of advanced wastewater treatment.
- Of theory for physical, chemical and microbial treatment and separation processes.
- Of treatment for nutrients (nitrogen and phosphor).
- Of anaerobic processes in activated sludge.
- Of physical separation processes.

Skills
- Shall be able to quantify the important biological, chemical and physical processes which is used for a process based wastewater treatment plant design.
- Shall be able to account for the interaction between the physical, microbial and chemical processes and the loading of the treatment plant.
- Shall be able to characterize wastewater.
- Shall be able to optimize wastewater treatment systems.
- Shall be able to design plants for mechanical and chemical treatment of wastewater.
- Shall be able to understand to design activated sludge and biofilm treatment plant for removal of carbon, nitrogen and phosphor.
- Shall be able to understand biological mineralization processes of carbon, nitrogen and phosphor and model these

Competences
- To plan and design new treatment plants.
- To analyze the function of existing treatment plants.
- To structure and produce technical documentation of complex problems, methods and results.
- To communicate problems, findings and results graphically as well as oral to the relevant target audience.

Type of instruction
Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests

Exam format
Individual oral or written exam. Exam format is decided on by start of semester. The level of complexity of exercises/demands for the master students attending the course is increased in comparison with the bachelor students attending the course.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.4 Water and Environmental Engineering 3rd Semester

3.4.1 Numerical Modelling and Experimental Methods – Option A
Numeriske og eksperimentelle metoder

Prerequisites
The module adds to the knowledge obtained in Hydrodynamics and Time Series Analysis, Measurement Technology and Data Acquisition, Advanced Hydrodynamic Modelling (CFD) and Visualization.

Objective
The aim of the project is to make the student able to measure model, analyze and visualize fluid dynamics and transport of substances in soluble or particle form. Emphasis in the project is on development of a strategy for measuring and modelling of selected situations - either with its own model or with a commercial model. The project also aims to get the students to evaluate critically the use of both measurements and models.

Knowledge
- Shall have knowledge on how numerical methods and experiments methods complement each other and how to use experimental data to improve numerical models.
- Shall have knowledge on how uncertainties are associated to each method and how they can be analyzed.

Skills
- Be able to measure, model, analyze and visualize fluid dynamics and transport of substances in soluble or particle form.
- Understand key methods for measuring water and turbulent transport.
- Calculate currents and turbulent transport with commercial available models.
- Develop independent numerical models.
- Plan and carry out the measurement program for field and laboratory measurements.
- Analyze errors and uncertainties in the measurement and modelling in natural or environmental engineering systems.

Competences
- Be able to combine experimental data and numerical methods to develop better models within the area of water and environment.
- To structure and produce technical documentation of complex problems, methods and results.
- Present and communicate results in a web-based media.
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work.

Type of instruction
Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format
Oral exam based on presentation seminar and project rapport.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.4.2 Advanced Urban Drainage – Option B
Videregående afløbsteknik

Prerequisites
The module adds to the knowledge obtained in Urban Drainage and Hydraulics.

Objective
The aim of the project is to qualify the student to understand different aspects of advanced urban waste and storm water runoff. This includes the ability to use different numerical modelling tools to analyze complex drainage systems with regards to transport of water and solids in both dry and wet weather including simulation of flooding and combined sewer overflow. The student shall also be able to estimate the consequence of climate change and propose solutions.

Knowledge
- Shall have knowledge on how urban wastewater and stormwater runoff interacts with our cities and its surrounding environment.
- Understand how this impact can be controlled by using advanced analysis and numerical modelling.

Skills
- Understand rainfall processes and transport of storm water on urban surfaces.
- Be able to evaluate the consequences of climate change for urban drainage systems.
- Combine knowledge on hydrodynamic performance of the storm drainage system with knowledge on the consequences in the receiving waters.
- Design a water management strategy for city areas so they can cope with increased precipitation.

Competences
- Be able to plan the drainage structure for an entire city with respect to flooding, receiving water quality and climate change.
- To structure and produce technical documentation of complex problems, methods and results.
- Present and communicate results in a web-based media
- Must be able to contribute successfully to teamwork within the problem area and make a common presentation of the result of the project work.

Type of instruction
Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format
Oral exam based on presentation seminar and project rapport.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.4.3 Advanced Hydrodynamic Modelling (CFD) and Visualisation (C)
Avanceret hydrodynamisk modellering (CFD) og visualisering

Prerequisites
The module adds to the knowledge obtained in Hydrodynamics.

Objective
The aim of the course is: (1) to make the student able to model hydrodynamic processes in both simple and complex flow structures, (2) to make the student able to visualize scientific and technically data, model results and measurements. Emphasis in the course is on practical application of commercial programs for modelling, analysis and data presentation.

Knowledge
- Shall have knowledge on how problems concerning complex process and flow structures can be approached numerically.
- Shall have knowledge on numerical errors, stability and accuracy of computational fluid dynamic models.
- Shall have knowledge on how result data can be represented graphically static and dynamically.

Skills
- Be able to set up a computational fluid dynamic model for a simple and more complex laminar and turbulent flows.
- Be able to choose appropriate boundary condition for the model.
- Be able to calibrate and validate models and interpret results.
- Be able to represent data in time and space based on data generated by field measurements or numerical models.
- Data animation.

Competences
- To structure, simulate and interpret numerical fluid models.
- To structure and produce documentation of complex problems.

Type of instructions
Lectures, etc. supplemented with project work, workshops, presentations seminars and lab tests.

Exam format
Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.4.4 Measurement Technology, Data Acquisition, Test and Validation (C)
Måleteknik og dataopsamling

Prerequisites
The module adds to the knowledge obtained in Basic Programming, Applied Statistics and Probability Theory.

Objective
The aim of the course is to enable the student to perform measurement and data acquisition in the laboratory and in the field. The course is equally divided between sensor technology and data acquisition with computers and data loggers.

Knowledge
- Knowledge on the different sensors available and the fundamental measuring principles.
- Knowledge on the computer based data acquisition, accuracy and error handling.
- Understand methodology for design of experiments and test series and for reduction of ambiguity of experimental results, and for comparability with model predictions.
- Understand processing methods for analog and digital data (continuous vs. discrete).

Skills
- Isolate principal measurable parameters.
- Be able to plan experiments in order to get optimal information compared to the experimental effort.
- Be able to choose the right sensor technology for the problem at hand.
- Setting up the A/D and D/A converters with commercial programs or by own programs.
- Isolate principal measurable parameters.
- Basic knowledge on digital image analysis.

Competences
- Be able to plan a laboratory or field experiment and setup appropriate data acquisition.
- Be able to discuss validity of results and errors of the data acquired in relation to choice of sensor and analysis method.

Type of instruction
Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format
Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.4.5 Urban Hydroinformatics (C)
Urban hydroinformatik

Prerequisites
The module adds to the knowledge obtained in Hydrodynamics and Analysis of Time Series, Ground Water Modelling, Hydraulics and Urban Drainage.

Objective
The aim of the course is to understand and apply advanced hydroinformatic models in analysis of complex hydrological, hydraulic, biological, and chemical processes related to transport of pollutants and water and decomposition of pollutants in urban drainage systems.

Knowledge
- Must have knowledge on complex hydrological, hydraulic, chemical, and biological processes in urban drainage systems.
- Must have knowledge on different numerical models for simulation of relevant complex processes in drainage systems.

Skills
- Must be able to apply commercial models for simulation of relevant processes in drainage systems.
- Must be able to develop and code simple models for simulation of relevant processes in drainage systems.
- Must be able to apply methods for calibration and validation of models.
- Must be able to apply probabilistic methods in order to quantify uncertainties in urban drainage models.

Competences
- Must be able read and understand scientific papers and apply novel methods within urban drainage modelling.
- Be able to compare observations and simulation results and discuss validity of the latter.

Type of instruction
Lectures, etc. supplemented with project work, workshops, presentation seminars, lab tests.

Exam format
Individual oral or written exam. Exam format is decided on by start of semester.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.4.6 Academic Internship
Projektorienteret forløb i en virksomhed

Prerequisites
The module adds to the knowledge obtained in 1st and 2nd Semester.

Objective
Students who complete the module:

Knowledge
- Must have knowledge about analytical, numerical and/or experimental methods for investigation of advanced problems within the company's field.

Skills
- Must be able to apply advanced analytical, numerical and/or experimental methods for analysis and assessment of advanced problems within the company's field.
- Must be able to compare and evaluate limitations and uncertainties related to the methods used for solving advanced problems within the company's field.

Competences
- Must be able to apply proper terminology in oral, written and graphical communication and documentation of problems and solutions within the company's field.
- Must be able to communicate the results of the project work in a project report.

Type of instruction
Internship in a company and project work. The study board must approve on the content of the project work before the internship is commenced.

Exam format
Oral exam based on presentation seminar and project rapport.

Evaluation criteria
As stated in the Joint Programme Regulations.

3.5 Water and Environmental Engineering 4th Semester

3.5.1 Master's Thesis
Kandidatspeciale

The master thesis can be conducted as a long master thesis using both the 3rd and 4th Semester. If choosing to do a long master thesis, it has to include experimental work and has to be approved by the study board. The amount of experimental work must reflect the allotted ECTS.

Prerequisites
The module adds to the knowledge obtained in the first three semesters of the master programme.

Objective
After completion of the project, the student should within the following topics:

Knowledge
- Have knowledge and comprehension within the field of the specialization at the highest international level.
- Be able to critically evaluate knowledge and identify new scientific problems within the field of the specialization.
- Have understanding of implications within the related research area including research ethics.

Skills
- Independently explain choice of scientific theoretical and/or experimental methods.
- During the project and when finalising it make an independent and critical estimation of the chosen theories and methods as well as the analyses, results and conclusions.
- Be able to apply a wide range of engineering methods in research and development in the field of specialization.
- Be able to communicate relevant scientific and professional aspects of project work in a clear and systematic way both to specialists and the public.

Competences
- Be able to work independently with a project on a specific problem within the field of the specialization at the highest international level.
- Independently be able to define and analyse scientific problems and based on that make and state the reasons for the decisions made.
- Be competent to solve new and complicated technical problems by the use of advanced mathematics, scientific and technological knowledge.
- Be able to evaluate the progress of the project independently and select and include additional literature, experiments or data when needed in order to maintain a scientific basis for the project.
- Be able to control complex and unexpected working situations and be able to develop new solutions.
- Must be able to communicate the results of the project work in a project report.

Type of instruction
Project work with supervision supplemented with instructions, workshops, presentation seminars, lab tests, etc.

Exam format
Oral exam based on presentation seminar and project rapport.

Evaluation criteria
As stated in the Joint Programme Regulations.

Chapter 4: Entry into Force, Interim Provisions and Revision

The curriculum is approved by the Dean of the Faculty of Engineering and Science and enters into force the 1. September 2017 for all new, enrolled students and the students who begin on the third semester MSc on 1st September 2017.

Chapter 5: Other Provisions

5.1 Rules concerning written work, including the Master's thesis

In the assessment of all written work, regardless of the language it is written in, weight is also given to the student's spelling and formulation ability, in addition to the academic content. Orthographic and grammatical correctness as well as stylistic proficiency are taken as a basis for the evaluation of language performance. Language performance must always be included as an independent dimension of the total evaluation. However, no examination can be assessed as 'Pass' on the basis of good language performance alone; similarly, an examination normally cannot be assessed as 'Fail' on the basis of poor language performance alone.
The Board of Studies can grant exemption from this in special cases (e.g., dyslexia or a native language other than Danish).

The Master's thesis must include an English summary.[1] If the project is written in English, the summary must be in Danish.[2] The summary must be at least 1 page and not more than 2 pages. The summary is included in the evaluation of the project as a whole.

5.2 Rules concerning credit transfer (*merit*), including the possibility for choice of modules that are part of another programme at a university in Denmark or abroad

In the individual case, the Board of Studies can approve successfully completed (passed) programme elements from other Master's programmes in lieu of programme elements in this programme (credit transfer). The Board of Studies can also approve successfully completed (passed) programme elements from another Danish programme or a programme outside of Denmark at the same level in lieu of programme elements within this curriculum. Decisions on credit transfer are made by the Board of Studies based on an academic assessment. See the Joint Programme Regulations for the rules on credit transfer.

5.3 Rules for examinations

The rules for examinations are stated in the Examination Policies and Procedures published by The Technical Faculty of IT and Design, The Faculty of Engineering and Science, and the Faculty of Medicine on their website.

5.4 Exemption

In exceptional circumstances, the Board of Studies study can grant exemption from those parts of the curriculum that are not stipulated by law or ministerial order. Exemption regarding an examination applies to the immediate examination.

5.5 Rules and requirements for the reading of texts

At programmes taught in Danish, it is assumed that the student can read academic texts in modern Danish, Norwegian, Swedish and English and use reference works, etc., in other European languages. At programmes taught in English, it is assumed that the student can read academic text and use reference works, etc., in English.

5.6 Additional information

The current version of the curriculum is published on the Board of Studies' website, including more detailed information about the programme, including exams.

[1] Or another foreign language (upon approval from the Board of Studies.
[2] The Board of Studies can grant exemption from this.