Programme Annex to the Teaching and Examination Regulations for the Bachelor's Programme in Applied Mathematics

The rules in this Annex are part of the programme portion of the Student Charter, including the Teaching and Examination Regulations for the Bachelor's programme in Applied Mathematics offered by the Faculty of Electrical Engineering, Mathematics and Computer Science of the University of Twente.

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1. CONTENTS AND STRUCTURE OF THE PROGRAMME[1]

(including the Programme Intended Learning Outcomes (PILOs))

a. The content of the programme and the associated examinations

Students who started the programme on September 1st 2018 or later will pass the final Bachelor's degree audit for Applied Mathematics once they have passed all study units as listed in Table 1, Table 2 and Table 3 in the Appendix.

Students who started the programme between September 2013 and September 2017 will pass the final Bachelor's degree audit for Applied Mathematics once they have passed all study units as listed in Table 4, Table 5 and Table 6 in the Appendix.

Students who started the programme prior to September 1st 2013 will pass the final Bachelor's degree audit for Applied Mathematics once they have passed all study units as listed in Table 7, Table 8 and Table 9 in the Appendix. These study units are no longer offered, so these students will have to make use of the transitional arrangements in Section 4 of this Annex.

Table 2 in Annex 1 contains a curriculum that has been adjusted for the combined final degree audit for Applied Mathematics and Applied Physics. Annex 1 contains specific rules and regulations of the double degree Applied Mathematics and Applied Physics.

Table 1 in Annex 2 to this Annex contains a curriculum that has been adjusted for the combined final degree audit for Applied Mathematics and Technical Computer Science. Annex 2 contains specific rules and regulations of the double degree Applied Mathematics and Technical Computer Science.

b. The content of the specialisations offered by the programme

The programme offers a single specialisation. The content of this specialisation is listed in the Appendix to this Annex.

c. The Programme Intended Learning Outcomes

The programme covers four fields of competence:

a. domain expertise;
b. research and modelling skills;
c. professional skills;
d. academic reflection.

These fields of competence are specified further in eleven PILOs:

1. The graduate has thorough knowledge of mathematical theories in the areas of algebra, analysis, statistics, stochastics, and discrete mathematics, and an understanding of the application of these theories in technology, health care and business administration (associated with domain expertise).

[1] The letters associated with the various paragraphs refer to the corresponding letters in Article 7.13, paragraph 2 of the Higher Education and Research Act (WHW).

2. The graduate can deal with abstraction, is capable of formal reasoning and can construct mathematical proofs (associated with domain expertise).
3. The graduate can use various research methods to answer research questions (associated with research and modelling skills).
4. The graduate can design and analyse mathematical models for problems of a multidisciplinary nature and assess their usefulness in practical situations (associated with research and modelling skills).
5. The graduate is proficient in using a computer to address the increasing size and complexity of mathematical problems. Computer algebra, numerical methods and simulations are key applications in this regard (associated with research and modelling skills).
6. The graduate is information literate. The graduate is adept at making the most of the library's resources, including advanced search methods in modern library networks (associated with research and modelling skills and professional skills).
7. The graduate is proficient in oral and written communication, and is able to work effectively in a team. The graduate is capable of continuously developing collaborative skills.
8. The graduate has insight into the position of the field of applied mathematics in society and has acquired a basic understanding of the philosophy of science (associated with academic reflection).
9. The graduate can shape his/her learning process, his/her competencies and develop his/her professional identity, by consciously choosing, motivating and completing study units that match personal capacities, skills, and motivation.
10. The graduate is aware of the opportunities for further specialisation in a Master's programme or for finding gainful employment (associated with academic reflection).
11. The graduate is interculturally competent.

d. Structure of practicals

Practicals are not subject to any specific provisions with regard to their structure.

e. Study load of the programme and of each of the study units in the programme

The study load of the study units is indicated in Table 1, Table 2, and Table 3.

f. Specific rules regarding Binding Recommendation (BSA)

Students pursuing a double degree in Applied Physics and Applied Mathematics are subject to an additional BSA provision: the BSA may involve exclusion from the Applied Mathematics programme if the student fails to earn 15 or more EC from the AM- study units associated with the double degree programme. See Table 2 in Annex 2 for the specific study units.

Students pursuing a double degree in Technical Computer Science and Applied Mathematics are subject to an additional BSA provision: the BSA may involve exclusion from the Applied Mathematics programme if the student fails to earn 15 or more EC from the AM-study units associated with the double degree programme. See Table 1 in Annex 2 for the specific study units.

g. Study load of the Master's programme

Not applicable.

h. The sequence of examinations

The sequence of examinations with relation to academic prerequisites is indicated in the Appendix of this Annex.

i. Programme format

The programme is offered on a full-time basis.

j. Sequence and periods for examinations and degree audits

The schedules indicate the tests that make up an examination. Degree audits are not restricted to specific periods.

k. Not applicable

l. Teaching method and assessment and examination formats

The teaching method for the various study units is indicated in the Appendix of this Annex. The following abbreviations are used:

Lec	Lecture,
Tu	Tutorial,
PR	Practical,
COL	Colstruction,
SS	Self Study.

The examination format for the study units is indicated in the Appendix of this Annex. The following abbreviations are used:

W	Written examination,
Or	Oral examination,
O	One or more assignments: the student submits work (assignments, reports, essays, other documents) and the examiner assesses it without the student being present,
P	Practical assignment: the student creates and submits a product that can be activated and subsequently assessed on behaviour and/or function and/or usability (e.g. a working program or a functioning prototype),
Pj	Project: the student participates in a number of group activities. The student will be assessed both on his individual contribution to the activities and the group's products (report, presentation, program),
Ps	Presentation: the student gives a presentation to the examiner and a group of interested people, generally fellow students.

These codes indicate the nature of assessment, without prescribing any rules for assessment.

m. See Guideline, Article 7.1.

n. See Guideline, Article 4.5.

o. See Guideline, Article 4.6.

p. See Guideline, Article 4.8.

q. See Guideline, Article 4.8.3.

r. See Guideline, Article 3.4.

s. Admission standards for examinations and practicals

The admission standards are listed in the Appendix of this Annex.

t. Required participation in a practical exercise as a component of an examination

The ‘form of assessment’ column in Table 1, Table 2, and Table 3 in the Appendix to this Annex shows whether participation is required in a practical exercise as a component of an examination.

u. See Guideline, Articles 6.1 and 6.2.

v. Not applicable

2. BRIEF DESCRIPTION OF MODULES 1-8, 11, 12

For each module we mention the *module intended learning outcomes.* For the more detailed intended learning outcomes for the module parts we refer to Osiris and the Learning Management System.

2.1 Module 1. Structures and Models

This module is the first acquaintance with studying Applied Mathematics. The ingredients are: abstract and formal reasoning (Calculus I, Prooflab I, Linear Structures I), programming and modelling (project with MATLAB) and calculus (Calculus I). None of the ingredients can be missed without significantly sacrificing one or more aspects of Applied Mathematics. Therefore, the core of the module coincides with the module itself.

The intended learning outcomes are: After successful completion of the module, the student:

- is aware of what it means to study applied mathematics at an academic level.
- knows and can apply the very basics of mathematics and modelling in about every subsequent module.

2.2 Module 2. Mathematical Proof Techniques

This module is primarily about abstraction and formal reasoning, studied from different perspectives: Linear Structures II, Analysis and Linear Optimization. A second binding factor is the project: Prooflab II. Furthermore, Calculus II and Analysis are strongly connected. Therefore, the core of the module coincides with the module itself.

The intended learning outcomes are: After successful completion of the module the student:

- is proficient in abstract and formal reasoning in basis mathematics.
- has an overview of proof techniques.
- is able to assess and understand complex proofs and is able to derive proofs in a systematic way.

2.3 Module 3. Fields and Electromagnetism

This module is centred around vector calculus and its applications in physics. The module is a joint effort of Applied Mathematics and Applied Physics. In the project students build electromagnetic devices from a historical perspective using modern materials. The module has a strong cohesion as almost all parts are intertwined. Therefore, the core of the module consists of all subjects except for the Presentation Skills. In presentation skills the students gain tools for presenting mathematical topics.

The intended learning outcomes are: After successful completion of the module the student:

- is able to use vector calculus in basic electromagnetic problems, both on a theoretical and a practical level.
- is able to concisely convey mathematical concepts using presentation skills.

2.4 Module 4. Signals and Uncertainty

This module has two building blocks. One is an introduction in the mathematical foundation of probability theory and the other is the introduction to frequency domain based tools to analyse signals as well as differential equations.

These building blocks are connected through the project. Collaboration in relatively large groups is a focus point of the project. The project is chosen such that both core topics play a crucial role. The goal of the project is to make a prediction of signals where the modelling requires frequency domain tools but the accuracy of the prediction can only be assessed using probability theory. For the project it is important that the student follows the module as a whole.

The intended learning outcomes are: After successful completion of the module the student:

- has knowledge of and insight into probability models, and is able to analyse them and interpret the outcomes.
- has knowledge of and insight into frequency domain analysis and ability to understand both signals and differential equations better using frequency domain tools.
- is able to analyse large amounts of data, using, in particular, frequency domain tools and, working together, obtain predictions and understand the accuracy of those predictions.

2.5 Module 5. Statistics and Analysis

The core of this module is formed by Mathematical Statistics and the project. The project deals with regression analysis. There are two standalone subjects in the module: the second part of Analysis and Reflection. Analysis II is part of the learning line in Analysis and Linear Structures. Reflection is part of the Reflection learning line.

The intended learning outcomes are: After successful completion of the module, the student:

- is able to derive mathematically the standard techniques for statistical data analysis and apply them properly.
- is able to work with infinite series of real numbers and functions, with metric spaces and with differentiability of functions in *n*-dimensional Euclidean spaces.

2.6 Module 6. Dynamical Systems

This module is about dynamic phenomena, their mathematical representations, computational aspects and applications in control problems. The subjects of the module are Ordinary Differential Equations (ODEs), Systems & Control and Numerical Analysis. For the project, students model a human movement and study it regarding stability and control, applying the material from the subjects. As the model has to be an ODE, this renders the core of the module to be the module itself.

The intended learning outcomes are: After successful completion of the module, the student

- is able to analyse and control solutions of systems of ODEs.
- can model a physical system with ODEs.

- is able to use various numerical and analytical techniques to study the model.

2.7 Module 7. Discrete Structures and Efficient Algorithms

This module deals with discrete problems as encountered in various practical problems and solutions thereof using efficient algorithms. The module is a joint effort of Applied Mathematics and Technical Computer Science. Central in the module is a project about graph isomorphisms. The theoretical parts that are used and needed in this project are Discrete Structures & Algorithms and Algebra & Finite Automata. The module also contains a training in Python. The core of the module coincides with the module itself.

The intended learning outcomes are: After successful completion of the module the student:

- has knowledge of and insight into discrete structures as studied in mathematics and computer science.
- is able to apply the techniques to analyse these structures and to solve relevant problems through appropriate algorithms.
- is able to deduce the complexity and efficiency of such algorithms.

2.8 Module 8. Modelling and Analysis of Stochastic Processes for Math

This module is about modelling situations with uncertainty using stochastic processes. The module is a joint effort of Applied Mathematics, Industrial Engineering and Management and Civil Engineering. The theoretical parts are closely connected (Stochastic Models being focused on applicability, while Markov Chains is more in depth), and Project Stochastic Models is closely related to Stochastic Models itself. Furthermore, all three projects are about the same context, the final project serving to integrate all acquired knowledge. Therefore, the core of the module coincides with the module itself.

The intended learning outcomes are: After successful completion of the module the student:

- knows how to recognise when a situation or system should be modelled using stochastic models.
- is able to select the most appropriate models.
- has knowledge of and insight into methods to analyse and/or simulate such models.
- is able to interpret the outcomes of the analysis or simulation.

2.9 Modules 11 and 12

The last semester of the programme contains the Reflection on Mathematical Research, Bachelor's Assignment, and Electives. Reflection on Mathematical Research II is the preparation of the actual Bachelor's Assignment. These parts are inseparable. Reflection on Mathematical Research I forms prior knowledge for the Bachelor's Assignment. The Electives and Complex Function Theory do not have a direct relation to the other parts.

3. SPECIFIC CHARACTERISTICS OF THE PROGRAMME

3.1 Language of tuition

English is the language of tuition - the examinations are administered in English. Exam and test questions have to be answered in English. Answers in any other language will be ignored and therefore not marked.

3.2 Transitional arrangement for cohorts 2015 and earlier

Students from cohort 2015 or earlier are entitled to language support.

3.3 Educational prerequisites

The following additional provisions apply with regard to the educational prerequisites in Article 2.1 of the general section of these Teaching and Examination Regulations.

Students with a first-year certificate from a technology programme at a university of applied sciences may be admitted to the Bachelor's programme in Applied Mathematics if they satisfy the following conditions:

- Colloquium doctum examinations for both Mathematics B and English
- Taking part in an Applied Mathematics matching activity. The programme's recommendation following the matching activity is binding.

3.4 Registration of results

- Exemptions for tests are indicated with the code 'VR'. They are assigned a numerical value of 6 for weighting purposes. Exemptions for modules are also indicated with the code 'VR', but they are not assigned a numerical value.
- The student thus has the option of requesting an exemption with the consequence that the exemption be assigned a value of 6 for weighting purposes, or the student may decide to take the test and possibly earn a higher mark.
- The results of complete (V) and incomplete (NVD) have no numerical values.
- The highest mark achieved counts. This also applies to tests.

3.5 Pass/Fail regulation

Students who meet the following requirements will pass the Bachelor's final degree audit for the Applied Mathematics programme:

a. The student has received an assessment for all study units of the Bachelor's final degree audit;
b. The student's marks are 6 or higher for all study units;

In all other cases, the student will not pass the final degree audit.

3.6 Cum Laude (with distinction)

A student may pass the Bachelor's final degree audit with distinction (cum laude). As a guideline for determining whether to award a degree with distinction, all of the following conditions should be met:

a. The student passes the Bachelor's final degree audit within four years after initial enrolment (performance requirement);
b. The student's average mark is 8.0 or higher (non-numeric assessments not included). This is a weighted average based on the corresponding number of ECs per study unit.
c. Mark 6 for at most one study unit.
d. The Bachelor's Assignment receives a mark of 8 or higher.

In exceptional cases and at the student's request, the Examination Board may award the distinction of cum laude if the student has met all requirements with the exception of the performance requirement, due to extenuating circumstances. These circumstances may involve delays recognised and provided for by the institution. It should be noted that the distinction of cum laude is never awarded automatically.

3.7 Period of validity of exam results

- The following applies to Modules 1, 2,4, 6, 7 and 8:
  Test results are only valid in the academic year in which they are obtained.
- The following applies to Module 3:
  Presentation skills pass grade remains valid indefinitely.
- The following applies to Module 5:
  If the results for Mathematical Statistics and Project are both a pass, then these results remain valid indefinitely. Pass grades for Analysis II and Prooflab Revisited remain valid indefinitely.
- For Module 9 and 10, the minor, the rules of the organising programme apply.
- The following applies to Modules 11 and 12:
  The test result for Reflection on Mathematical Research I, the Electives, and Complex Function Theory, see Table 3, remain valid indefinitely. The results of Reflection on Mathematical Research II and Bachelor's Assignment remain valid indefinitely only if they both are a pass.

3.8 BSA rules

The programme uses the Osiris BSA module in its entirety.

- The binding recommendations (BSA) are issued based on the results of the modules. At the conclusion of Module 1, the recommendation may be positive, negative or neutral.
- There are two types of official recommendations: an interim recommendation and a final recommendation.
- These official recommendations are issued by the Programme Board.
- The letters containing the binding recommendations are based on the 'Guideline for Teaching and Examination Regulations for Bachelor's Programmes' and the recommendations referred to above.
- The letters containing the binding recommendations are sent digitally.
- A digital signature is automatically appended to the binding recommendation letters.

3.9 Compensation scheme

The Compensation scheme applies to a number of clusters as defined in this regulation. These clusters may be confined to individual modules, but they may also extend over multiple modules.

Cluster I: Linear Structures I from Module 1 (201800135), Linear Structures II and Analysis I from Module 2 (201800136)

Cluster II: Module 4 (201800138)

Cluster III: Module 5 (201800139)

Cluster IV: Module 6 (201500103)

Cluster V: Module 7 (201800141)

Cluster VI: Module 8 (201400434)

In each cluster, a student must:

- Achieve a weighted average mark of at least 5.5;
- Have no more than one mark lower than 5.5;
- Have no marks lower than 4.5;
- Achieve a weighted average mark of at least 5.5 for both modules in the case of compensation in cluster I;
- Meet the condition that the weighted average mark of Analysis I and Analysis II is at least 5.5 and the weighted average mark of Probability Theory and Mathematical Statistics is at least a 5.5 in the case of compensation in cluster III.

If the Compensation scheme is applied to a module, the final mark for that module is the weighted average of the components calculated according to the formula used if all components have been passed with a mark of at least 5.5.

The Compensation scheme may be applied once in the first academic year of the Bachelor's programme.

The Compensation scheme may be applied once in the second academic year of the Bachelor's programme.

The Compensation scheme may only be invoked for modules in which all components are completed in the course of a single academic year.

3.10 Study units available to students as Electives

Table 6 shows the electives available to students who joined the programme on or after September 1st 2013.

Table 7, Table 8 and Table 9 show the electives available to students who joined the programme prior to September 1st 2013. Exams are no longer held for the electives in Tables 7, 8 and 9.

The Minor profile is in Table 3. See Paragraph 3.11 for more information.

3.11 Minor profile

Students may choose from among the minors offered by the University of Twente, or they may compose their own proposal and submit it to the Examination Board for approval. The proposal for the minor must meet the following conditions:

- The minor's academic level must be assured (to be assessed by the Examination Board).
- The minor's components are to be cohesive.

3.12 Secondary school teaching certificate

Students who pass the 30-EC minor *Leren Lesgeven*[2] receive, alongside a Bachelor's degree in Applied Mathematics, a mathematics teaching qualification for the initial years of senior general secondary education (HAVO), pre-university education (VWO), and the theoretical learning pathway of pre-vocational secondary education (VMBO) in the Netherlands.

3.13 Bachelor's Assignment confidentiality

Reports of Bachelor's Assignments are public documents except in the cases listed below.

The Programme Board may deem a report to be confidential for a specific period based on a detailed request:

a. The first supervisor must submit a request to the Programme Board prior to the start of the final assignment.
b. The confidential report must be accessible/available to the committee responsible for assessing the Bachelor's Assignment, the Programme Board, and representatives of bodies that have a statutory duty of overseeing the quality of the assessment or the programme as a whole.
c. The parties mentioned above are required to respect confidentiality with regard to the report.

3.14 Double Degree programmes

The programme offers two double degrees: Applied Mathematics combined with Applied Physics, and Applied Mathematics combined with Technical Computer Science.

A tailored curriculum applies to students pursuing a double degree in Applied Physics and Applied Mathematics, as detailed in Annex 1, Table 2.

The table lists the components of the study units. In each quarter, the components listed under Applied Mathematics form a cohesive study unit, as do the components under Applied Physics. See Annex 1 for the specific rules and regulations of the double degree Applied Mathematics and Applied Physics.

A tailored curriculum applies to students pursuing a double degree in Technical Computer Science and Applied Mathematics, as detailed in Annex 2**,** Table 1. The table lists the components of the study units. In each quarter, the components listed under Applied Mathematics form a cohesive study unit, as do the components under Technical Computer Science. See Annex 2 for the specific rules and regulations of the double degree Applied Mathematics and Technical Computer

[2] The minor *Leren Lesgeven* is only available in Dutch.

Science.

3.15 Evaluation of education

To monitor and to improve the quality of teaching, the AM BSc programme uses information about the students' learning experiences. This information is obtained from:

a. Internal evaluations
    - SEQ (Student Experience Questionnaire)
    - Panel discussions with students and teachers
b. External sources
    - National Student Survey (NSE)
    - National Alumni Survey
    - International Student Barometer

4. TRANSITIONAL ARRANGEMENTS

4.1 Transitional arrangements for students of cohorts 2009 and earlier

A student who started the programme in September 1st 2009 and earlier and who passed the course Random Signals and Systems (191571080) may use this course as the elective course Random Signals and Filtering (201200135).

4.2 Transitional arrangements for students of cohorts 2012 and earlier

4.2.1. Bachelor's Assignment

The Bachelor's Assignment is an individual assignment combined with Reflection on Mathematical Research. Together, this amounts to 17 EC. Students of cohort 2012 cohort or earlier may submit a substantiated request to the Examination Board if they wish to deviate from the current structure involving an assignment combined with Reflection on Mathematical Research.

4.2.2. Minor

Students in the 2012 cohort or earlier are allowed to take a minor of a study load between 15 and 30 EC.

4.2.3. Discontinued courses

Students who still need to complete courses for which exams are no longer offered and for which there is no transitional arrangement provided, must contact the Study Advisor. An attempt will then be made to find study units from the current curriculum that cover the missing learning goals. The replacement has to be approved by the Examination Board.

4.2.4. Bachelor's degree audit

Students who started the programme on September 1st 2012 or earlier will pass the Bachelor's degree audit once they have satisfied the following conditions:

- All study units from the first year of a Bachelor's curriculum from before September 1st 2013 have been completed with a mark of 5 or higher and no more than one 5;
- All study units from the second and third year of a Bachelor's curriculum from before September 1st 2013 have been completed with a mark of 5 or higher and no more than one 5;
- The average of all marks is greater than or equal to 6;
- The mark for the Bachelor's Assignment is 6 or higher.

4.3. Transitional arrangements for students of cohort 2018 and earlier

1. A student who has not completed Module 1, has to follow the current version of Module 1 and the Intercultural Communicator workshop in Module 5.
2. A student of cohort 2017 or a previous academic year, who has not completed Module 2, has to follow the current version of Module 2.
3. A student of cohort 2017 or a previous academic year, who has not completed the module Fields and Electromagnetism, has to follow the current version of Module 3.
4. A student of cohort 2017 or a previous academic year, who has not completed the module Signals and Uncertainty, has to follow the current version of Module 4.

APPENDIX I: BACHELOR PROGRAMME AM

1. Table 1[3]: the first academic year

Components	Study load in EC	Teaching method	Form of assessment
201800135 M1 Structures and Models			
Calculus I (including Prooflab I)	4 EC	Lec +Tu	W+O
Linear Structures I	6 EC	Lec +Tu	W
Project: Programming and Modelling & Intercultural communicator workshop (practice)	5 EC	Lec + PR	Pj+P
201800136 M2 Mathematical Proof Techniques			
Calculus II	4 EC	Lec +Tu	W
Linear Structures II	3 EC	Lec +Tu	W
Analysis I	3 EC	Lec +Tu	W
Linear Optimization	3 EC	Lec +Tu	W
Prooflab II	2 EC	SS + Tu	O
201800137 M3 Fields and Electromagnetism			
Vector Calculus	2 EC	Lec +Tu	W
Prooflab III	1 EC	Lec +Tu	O
Electromagnetism	5 EC	Lec +Tu	W
Mathematica	1 EC	PR	P
Analytical Programming	1 EC	PR	P
Presentation Skills	2 EC	PR	Ps
Project	3 EC	Pj	P
201800138 M4 Signals and Uncertainty			
Signals & Transforms	5 EC	Lec + Tu	W
Probability Theory	5 EC	Lec + Tu	W
Project	5 EC	Lec + PR	Pj+P
Entire academic year	**60**		

[3] Article 1.l explains the abbreviations used in the columns 'teaching method' and 'form of assessment'.

2. Table 2: the second academic year

Components:	Study load in EC	Teaching method	Form of assessment
201800139 M5 Statistics and Analysis			
Mathematical Statistics	6 EC	Lec+Tu	W
Analysis II	5 EC	Lec+Tu	W
Project	2 EC	Lec+PR	Pr
Prooflab Revisited, including Intercultural communicator workshop (Theory)	2 EC	Lec	Pj + Ps
201500103 M6 Dynamical Systems			
Differential Equations & Numerical Methods	4,5 EC	Lec+Tu	W
Systems Theory and Numerical Methods	4,5 EC	Lec+Tu	W
Numerical Methods practical	2,25 EC	Lec+PR	W+P
Project	3,75 EC	PR	Pj
201800141 M7 Discrete Structures & Efficient Algorithms			
Algorithms and Data Structures + Discrete Mathematics	5 EC	Lec+Tu	W
Languages & Machines	3,5 EC	Lec+Tu	W
Algebra	3,5 EC	Lec+Tu	W
Project	3 EC	PR	Pj
201400434 M8 Modelling & Analysis of Stochastic Processes for Math			
Stochastic Models	5 EC	Lec+Tu	W
Stochastic Models Project	1,5 EC	PR	Pj
Markov Chains	2,5 EC	Lec+Tu	W
Stochastic Simulation Project	4 EC	PR	Pj+P
Multidisciplinary Project	2 EC	PR	Pj
Entire academic year	**60**		

3. Table 3[4]: the third academic year

Components	Study load in EC	Teaching method	Form of assessment	Sequence requirements
Minor profile M9 + M10	**30 EC**			1
201500379 M11 Bachelor's Assignment & Electives:				2
Reflection on Mathematical Research I	5 EC	Lec	O	
Electives: Two of the following four components must be included in the student's exam programme:				
Graph Theory	5 EC	Lec+Tu	W	
Mathematical Optimization	5 EC	Lec+Tu	W	
Random Signals & Filtering	5 EC	Lec	W	
Introduction to PDE	5 EC	Lec+Tu	W	
201500380 M12 Finalising Thesis – Bachelor's Assignment				2
Complex Function Theory	3 EC	Lec+Tu	W	
Reflection on Mathematical Research II	2 EC	Lec	O	
Bachelor's Thesis	10 EC	PR	P+Ps	
Entire academic year	**60**			

[4] Article 1.l explains the abbreviations used in the columns 'teaching method' and 'form of assessment'. Numbers in the column 'sequence requirements' refer to the text following the table.

Sequence requirement 1 (see table above): students may only participate in this study unit once they have gained at least 75 ECs.

Sequence requirement 2 (see table above): students may participate in this study unit once they have completed the first eight modules of the Applied Mathematics bachelor's programme. Students who have almost completed the first eight modules, may register for the electives in Module 11 and Complex Function Theory in Module 12 after approval by the AM Examination Committee.

4. Table 4[5]: the first academic year for cohorts 2013 until 2017

Components	Study load in EC	Teaching method	Form of assessment
201700118 Structures and Models			
Mathematics A + β1	4 EC	Lec+Tu	W
Linear Structures I	6 EC	Lec+Tu	W
Programming and Modelling	5 EC	Lec+PR	Pj+P
Includes: Intercultural Communicator workshop			
201700140 Mathematical Proof Techniques			
Mathematics β2	3 EC	Lec+Tu	W
Linear Structures II	3 EC	Lec+Tu	W
Analysis	3 EC	Lec+Tu	W
Linear Optimization	2 EC	Lec+Tu	W
Prooflab	4 EC	PR	O
201300182 Signals and Uncertainty			
Signals & Transforms	5 EC	Lec+Tu	W
Probability Theory	5 EC	Lec+Tu	W
Project	5 EC	PR	Pj
Includes: Intercultural Team workshop			
201400535 Fields and Electromagnetism			
Vector Calculus	5 EC	Lec+Tu	W
Electromagnetism	5 EC	Lec+Tu	W
Project	5 EC	Lec+PR	Pj+P
Entire academic year	**60**		

[5] Article 1.l explains the abbreviations used in the columns 'teaching method' and 'form of assessment'.

5. Table 5[6]: the second academic year for cohorts 2013 until 2017

Components	Study load in EC	Teaching method	Form of assessment
201400218 Statistics and Analysis			
Mathematical Statistics	6 EC	Lec+Tu	W
Analysis II	5 EC	Lec+Tu	W
Presentation Skills	2 EC	Lec+PR	Pr
Project	2 EC	PR	Pj
201500103 Dynamical Systems			
Differential Equations & Numerical Methods	4,5 EC	Lec+Tu	W
Systems Theory and Numerical Methods	4,5 EC	Lec+Tu	W
Numerical Methods practical	2,25 EC	Lec+PR	W+P
Project	3,75 EC	PR	Pj
201600270 Discrete Structures & Efficient Algorithms			
Discrete Structures & Algorithms	5 EC	Lec+Tu	W
Algebra & Finite Automata	6,5 EC	Lec+Tu	W
Research project: Similarity	3,5 EC	PR	Pj
201400434 Modelling & Analysis of Stochastic Processes for Math			
Stochastic Models	5 EC	Lec+Tu	W
Stochastic Models Project	1,5 EC	PR	Pj
Markov Chains	2,5 EC	Lec+Tu	W
Stochastic Simulation Project	4 EC	PR	Pj+P
Multidisciplinary Project	2 EC	PR	Pj
Entire academic year	**60**		

[6] Article 1.l explains the abbreviations used in the columns 'teaching method' and 'form of assessment'.

6. Table 6[7]: the third academic year for cohorts 2013 until 2017

Components:	Study load in EC	Teaching method	Form of assessment	Sequence requirements
Minor profile	**30**			1
201500379 Bachelor's Assignment prep Reflection on Mathematical Research I	5 EC	Lec	O	2
Two of the following four components must be included in the student's exam programme: Graph Theory Mathematical Optimization Random Signals and Filtering Introduction to PDE	10 EC 5 EC 5 EC 5 EC 5 EC	 Lec+Tu Lec+Tu Lec Lec+Tu	 W W W W	
201500380 Bachelor's Assignment Complex Function Theory Reflection on Mathematical Research II Bachelor's thesis	 3 EC 2 EC 10 EC	 Lec+Tu Lec PR	 W O P+Ps	2
Entire academic year	**60**			

[7] Article 1.l explains the abbreviations used in the columns 'teaching method' and 'form of assessment'. Numbers in the column 'sequence requirements' refer to the text following the table.

With reference to sequence requirement 1 (see table above): students may only participate in this study unit once they have gained at least 75 EC.

With reference to sequence requirement 2 (see table above): students may only participate in this study unit once they have passed the first eight modules of the Applied Mathematics programme.

7. **Table 7[8]: the first academic year for cohorts starting prior to September 1st 2013**

Components:	**Study load in EC**	**Form of assessment**
201100103 Calculus	5 EC	W+P
201100104 Vector Calculus	4 EC	W+P
201100100 Linear Structures I	5 EC	W
201100101 Linear Structures II	5 EC	W
191521611 Discrete Mathematics I	4 EC	W
191521631 Discrete Mathematics II	4 EC	W
191530370 Probability	5 EC	W
201100102 Analysis I	5 EC	W
191560123 Ordinary Differential Equations	4 EC	W
191580751 Deterministic Models in the OR	4 EC	W
191521501 Mathematical Modelling I	5 EC	Pj+O
191540160 Algorithms and Programming I	2 EC	P
194113000 Great minds in the history of science	3 EC	W or O
Elective:	5 EC	
191403021 Dynamics		W
191580612 Introduction to Mathematical Economics		W+P
Entire academic year	**60**	

[8] Article 1.l explains the abbreviations used in the columns 'teaching method' and 'form of assessment'.

8. Table 8[9]: the second academic year for cohorts starting prior to September 1st 2013

Components:	Study load in EC	Teaching method	Form of assessment
201100109 Signals and Transforms	5 EC	Lec +Tu+PR	W
191515603 Intr. to investment theory	5 EC	Lec+Tu	W
191530382 Mathematical Statistics	5 EC	Lec+Tu	W
191530651 Markov Chains	5 EC	COL	W
191540270 Numerical Math. and Modelling	5 EC	Lec+Tu+PR	W+P
191505001 Presenting a mathematical topic	2 EC	Ps	Pr
191540170 Algorithms and Programming II	3 EC	COL + PR	P
191560561 Intro to mathematical systems theory	5 EC	Lec+Tu+PR	W+P
191505271 Mathematical Modelling II	5 EC	Lec+PR	Pj+O
191521400 Analysis II	5 EC	Lec+Tu	W
191511410 Algebra and security	5 EC	Lec+Tu	W
Elective:	5 EC		
191403033 Dyn. Modelling and Simulation		Lec+PR	W+P
191530881 Stochastic models in OM		Lec+Tu	W
Elective:	5 EC		
191403051 Electricity and Magnetism		Lec+Tu	W
192111801 Basic models in computer science		Lec+Tu+PR	W+P
Entire academic year	**60**		

[9] Article 1.l explains the abbreviations used in the columns 'teaching method' and 'form of assessment'.

9. Table 9[10]: the third academic year for cohorts starting prior to September 1st 2013.

Components:	Study load in EC	Teaching method	Form of assessment
191530821 Stochastic Simulation Project	5 EC	Lec	P+Or
Elective:	5 EC		
191561620 Optimal control		Lec	W
201200135 Random Signals and Filtering		Lec	W
Elective:	5 EC		
191520751 Graph Theory		Lec+Tu	W
191550105 Theory of Partial Differential Equations		Lec+Tu	W
191530440 Regression and ANOVA	5 EC	Lec+PR	W+P
191520252 Complex Function Theory	5 EC	Lec+Tu	W
191580251 Mathematical Programming	5 EC	Lec+Tu+PR	W or Or
191599220 Bachelor's Assignment	10 EC		Pj+O
Minor	20 EC		
Entire academic year	**60**		

Requirements for the Bachelor's Assignment:
A student may only participate in this study unit once he has gained his first-year certificate and at least 60 EC from the second and third years of the Bachelor's curriculum, excluding the minor. Furthermore, the student must have completed the subjects listed as prerequisites for the relevant assignments, and he must have passed Mathematical Modelling II.

Requirements for the Minor:

At a specific date, to be announced in advance, the student must have gained at least 80 EC. The credit total includes the results of examinations from the fourth quarter (or directly subsequent to the fourth quarter), whereas results of examinations during the summer break will not be included. The Examination Board may grant dispensation from the 80-credit requirement in individual cases.

[10] Article 1.l explains the abbreviations used in the columns 'teaching method' and 'form of assessment'.

1. ANNEX TO THE TEACHING AND EXAMINATION REGULATIONS FOR THE DOUBLE DEGREE PROGRAMME APPLIED MATHEMATICS AND APPLIED PHYSICS

This annex contains the following paragraphs:

1. Double Degree Programme
2. Curriculum Study programme AM - AP
3. Transitional arrangements
4. Safety
5. Minor and Bachelor's Assignment
6. Binding Recommendation

1. Double Degree Programme

Students can choose to follow a double degree programme. The studying requirements are based on the Rules of the Examination Board AM and the AP Examination Board[11].

2. Curriculum

The tailored programme for the double degree programme for cohort 2018 and later is summarised below:

First academic year (79 EC)		
	Applied Mathematics *components*	***Applied Physics*** *components*
Quartile 1 *(21 EC)*	Linear Structures I (6 EC) Calculus I - including Prooflab I (4 EC) Intercultural communicator workshop (practice)	Dynamics & Relativity (5 EC) Experimentation 1 (1,5 EC) Programming & data processing 1 (2 EC) Project (2,5 EC)
Quartile 2 *(20 EC)*	Calculus II (4 EC) Linear Structures II (3 EC) Analysis I (3 EC) Linear Optimization (3 EC) Prooflab II (2 EC)	Thermodynamics (4 EC) Programming & data processing 2 (1 EC)
Quartile 3 *(18 EC)*	Prooflab III (1 EC) Presentation skills (2 EC)	Electromagnetism (5 EC) Vector Calculus (2 EC) Instrumentation (4 EC) Project (3 EC) Analytical programming (1 EC)
Quartile 4 *(20 EC)*	Probability Theory (5 EC) Signals and Transforms (5 EC) Project (5 EC)	Quantum Matter (5 EC)

[11] In the event of a change to the double degree programme as stated in Article 1, individual agreements will be made with the students by the examination committees of both programmes.

Second academic year (81,5 EC)		
	Applied Mathematics *components*	***Applied Physics*** *components*
Quartile 5 *(20,5 EC)*	Mathematical Statistics (6 EC) Analysis II (5 EC) Prooflab revisited (2 EC)	Models (4,5 EC) Project (3 EC)
Quartile 6 *(21 EC)*	Differential Equations & Numerical Methods (4,5 EC) Systems Theory and Numerical Methods (4,5 EC) Numerical Methods practical (2,25 EC) Project (3,75 EC)	Quantum Mechanics (6 EC)
Quartile 7 *(21 EC)*	Discrete Math & Algebra (6 EC)	Solid State Physics (7 EC) Statistical Physics (6 EC) PDE (2 EC)
Quartile 8 *(19 EC)*	Markov Chains (4 EC)	Physics of Fluids (7 EC) Electrodynamics (6 EC) Num. Meth. for PDE (2 EC)

***Third academic year* (67 EC)**

Quartile 9 **(15 EC)**	***Minors*** https://www.utwente.nl/en/education/electives/minor/

Quartile 10 **(17 EC)**		
	Applied Mathematics *components*	***Applied Physics*** *components*
Electives selection (10 EC)		
		Optics (7 EC)

Quartile 11 **(15 EC)**	**Bachelor's Assignment** ***Applied Mathematics*** *components*	***Applied Physics*** *components*
	Reflection on Mathematical Research I (5 EC) 10 EC of Electives: (other elective courses are possible in consultation with the programme)	
	Graph Theory (5 EC) Introduction to PDE (5 EC) Random Signals and Filtering (5 EC) Mathematical Optimization (5 EC)	Heat and Mass Transfer (5 EC) Physical Materials Science (5 EC) Technical Optics (5 EC) Computational Physics 1 (2,5 EC) Computational Physics 2 (2,5 EC) Intro. Instrumentation Comp (2,5 EC/5 EC)

Quartile 12 **(20 EC)**	**Thesis**
	Complex Function Theory (3 EC) Reflection on Mathematical Research II (2 EC) Bachelor's Assignment (15 EC)

3. Transitional arrangements

a. If the study programme described in Article 2 of this Annex is changed, the new Education and Examination Regulations replace the old ones; a transitional arrangement is established and announced by the Programme Board.
b. For the third year of cohort 2017 and earlier please refer to Table 7 of this Annex.
c. Curricula per year and accompanying transitional arrangements are published on the Applied Mathematics site: https://www.utwente.nl/en/bam/bachelors-curriculum/

4. Safety

Safety requirements are compulsory while working in a laboratory. The student is obliged to follow these rules.

5. Minor and Bachelor's Assignment

a. The minor consists of 15 EC (a quartile); The permitted minor offer is stated on the minor website https://www.utwente.nl/en/education/electives/minor/

b. Before the beginning of a unit of study, the student is expected to meet the prior knowledge requirements of that unit of study, as described in the minor's course catalogue.

c. At the start of a minor, the student must have obtained at least 75 EC (5 modules) from the B1 and B2 programs of the Bachelor's programme.

d. The student can only register for the Bachelor's Assignment examination component if he has fully passed the first year programme and if he obtained a minimum of 60 EC from the second and third year programme excluding the minor.

e. After the advice of the Examination Board, at the request of the student, the Programme Board may grant exemption from the condition referred in Paragraph a, Paragraph b, Paragraph c and Paragraph d of this article. This may cause a delay in the study progress.

6. Binding Recommendation (BSA)

With reference to the Teaching and Examination Regulations for the Bachelor's programme in Applied Mathematics Article 1.f: Students pursuing a double degree in Applied Physics and Applied Mathematics are subject to an additional BSA provision: the BSA may involve exclusion from the Applied Mathematics programme if the student fails to earn 15 or more EC from the AM-study units associated with the double degree programme. See Table 2 for the specific study units.

7. Table 7: Transitional arrangements Third year Cohort 2017

Quartile 9	
(15 EC)	*Minors* *https://www.utwente.nl/en/education/electives/minor/*

Quartile 10		
(15 EC)	***Applied Mathematics*** *components*	***Applied Physics*** *components*
	Differential Equations & Numerical Methods (4,5 EC) Systems Theory and Numerical Methods (4,5 EC) Numerical Methods practical (2,25 EC) Project (3,75 EC)	

Quartile 11		
(20 EC)	**Bachelor's Assignment**	
	Applied Mathematics *components*	***Applied Physics*** *components*
	Reflection on Mathematical Research I (5 EC) 15 EC of Electives: (other elective courses are possible in consultation with the programme)	
	Graph Theory (5 EC) Introduction to PDE (5 EC) Random Signals and Filtering (5 EC) Mathematical Optimization (5 EC)	Heat and Mass Transfer (5 EC) Physical Materials Science (5 EC) Technical Optics (5 EC) Computational Physics 1 (2,5 EC) Computational Physics 2 (2,5 EC) Intro. Instrumentation Comp (2,5 EC/5 EC)

Quartile 12	
(20 EC)	**Thesis**
	Complex Function Theory (3 EC) Reflection on Mathematical Research II (2 EC) Bachelor's Assignment (15 EC)

2. ANNEX TO THE TEACHING AND EXAMINATION REGULATIONS FOR THE DOUBLE DEGREE PROGRAMME APPLIED MATHEMATICS AND TECHNICAL COMPUTER SCIENCE

This annex contains the following paragraphs:

1. Study programme AM – TCS
2. Extra requirements for double degree AM - TCS
3. Elective section
4. Sequence requirements
5. Teaching evaluation
6. Pass/Fail Regulations
7. Cum Laude
8. Binding Recommendation
9. AM – TCS double degree programme cohort 2016 and 2017

1. Table 1: Study programme AM – TCS

The tailored programme for the double degree programme for cohort 2018 and later is summarised below:

Course-code	Course name	Q	EC	Division	Prerequisites
B1-fase (Year 1)					
201300312	Linear Structures I	1A	6	AM	
201700139	Introduction to Mathematics + Calculus 1A	1A	4	AM/TCS	
201700139	Pearls of Computer Science	1A	11	TCS	
201500112	Programming Theory & Project	1B	8	TCS	
201500365	Calculus 1B	1B	3	AM/TCS	
201300229	Analysis	1B	3	AM	
201400424	Prooflab II	1B	2	AM	
201300230	Linear Structures II	1B	3	AM	201300312
201400514	Network Systems	2A	12	TCS	
201400606	Vector Calculus EE + AT	2A	3	AM	
201400360	Presentation skills	2A	2	AM	
201400479	Signals & Transforms	2B	5	AM	
201400489	Probability Theory AM	2B	5	AM/TCS	
201600174	Data & Information	2B	12	TCS	201500112
B2-fase (Year 2)					
201800316	(Mathematical) Statistics	1A	6	AM/TCS	201400489
201800144	Project Statistics	1A	2	AM	
201900874	Computer Systems (Partial)	1A	12	TCS	
201400429	Systems Theory	1B	4	AM	
201400428	Differential Equations	1B	4	AM	201500365
201800421	Intelligent Interaction Design	1B	12	TCS	
201600061	Introduction Mathematical Modelling	2A	1	AM	
201600270	Discrete Structures & Efficient Algorithms	2A	15	AM/TCS	201400210
201400434	Modelling and Analysis of Stochastic Processes	2B	15	AM	

201600062	Project Signals & Uncertainty	2B	5	AM	
B3-fase (Year 3)					
201400358	Analysis II	1A	5	AM	
201400365	Discrete Mathematics (from Module 5, Computer Science)	1A	3	TCS	
201500566	Reflection I	1A	5	AM	
	Minor selection	1B	15	AM/TCS	All first year components
201500121	Design Project	2A	15	TCS	All components of 8 quartiles, included all first year components module 12: 201800155
	Elective AM selection	2A	5	AM	
201700274	Bachelor's Assignment double degree	2B	15	AM/TCS	
201500567	Reflection II	2B	2	AM	
201500405	Complex Function Theory	2B	3	AM	
	Total ECs	**223**			

2. Extra requirements for double degree AM – TCS:

The prospective student enrolled to the double degree programme AM – TCS must attend an extra intake / conversation to determine whether the student is motivated, ambitious and possess the skills needed to succeed in the double degree programme.

3. Elective section

1. The Elective section consists of one elective course and one minor module;
2. Available minors are listed on the minors site: **https://www.utwente.nl/en/education/electives/minor/**;
3. For an individual minor approval of the AM examination board is needed.
4. In the fourth quartile of the third year, one of the following courses must be included in the student's curriculum:

- Graph Theory
- Introduction to PDE
- Random Signals and Filtering
- Mathematical Optimization

4. Sequence requirements

1. A student may enrol in the minor through the Minor Bureau once he has completed the B1-fase upon registration in Osiris;
2. A student may only enrol in the Bachelor's Assignment once he has passed at least 8 quartiles of the complete programme. These 8 quartiles include all first-year components.

5. Teaching evaluation

1. All components of the programme are parts of modules. The online Student Experience Questionnaire (SEQ) is used for evaluation purposes at the conclusion of modules;
2. At least once a year there will be a panel of discussion with students participating in the double degree;
3. Additionally, there will be an extra panel discussion after the first semester of the first year.

6. Pass/fail regulations

1. Students who meet the following requirements will pass the Bachelor's final degree audit for the AM and the TCS programme:
   a. The student has received an assessment for all units of study of the double degree programme;
   b. The student's final results are 6 or higher for all units of study.

   In all other cases not specified under (1), the student will not pass the final degree audit for AM and TCS and will not receive the Bachelor's degrees.

7. Cum Laude

1. A student may pass the Bachelor's final degree audit for TCS and AM with distinction (cum laude) upon meeting the following requirements:
   a. The student passes the Bachelor's final degree audit for TCS and AM within four years of initial enrolment (performance requirement);
   b. The student's weighted average is 8.0 or higher (non-numeric assessments and exemptions not included). The average is weighted based upon the amount of credits.
   c. The mark for the Bachelor's Assignment is 8.0 or higher.
2. In exceptional cases and at the student's request, the Examination Board may award the distinction of cum laude if the student has met all requirements with the exception of the performance requirement, due to extenuating circumstances. These circumstances may involve delays recognised and provided for by the institution.

8. Binding Recommendation (BSA)

1. Students pursuing a double degree in Technical Computer Science and Applied Mathematics are subject to an additional BSA provision: the BSA may involve exclusion from the Applied Mathematics programme if the student fails to earn 15 or more EC from the AM-study units associated with the double degree programme. See Table 1 for the specific study units.

9. Table 9: Applied Mathematics - Technical Computer Science double degree programme cohort 2016 and 2017

First academic year: 81 EC

Quartile 1 (21 EC)	**Applied Mathematics**	**Technical Computer Science**
	Mathematics A & B1 (4 EC) Linear Structures I (6 EC)	Pearls of Computer Science (8 EC) Technical Computer Science Project (3 EC)
Quartile 2 (21 EC)	**Applied Mathematics**	**Technical Computer Science**
	Mathematics B2 (3 EC) Linear Structures II (3 EC) Analysis (3 EC) Prooflab (4 EC)	Programming Theory & Programming Project (8 EC)
Quartile 3 (20 EC)	**Applied Mathematics**	**Technical Computer Science**
	Signals & Transforms (5 EC) Probability part I (3 EC)	Network Systems (12 EC)
Quartile 4 (19 EC)	**Applied Mathematics**	**Technical Computer Science**
	Vector calculus (5 EC) Probability part II (2 EC)	Data and Information (12 EC)

Second academic year: 76 EC

Quartile 5 (20 EC)	**Applied Mathematics**	**Technical Computer Science**
	Statistics (5 EC)	Computer Systems (15 EC)
Quartile 6 (20 EC)	**Applied Mathematics**	**Technical Computer Science**
	Differential Equations (4 EC) Systems theory (4 EC)	Intelligent Interaction & Design (12 EC)
Quartile 7 (21 EC)	**Applied Mathematics**	**Technical Computer Science**
	Discrete Struct & Algorithms (5 EC) Algebra & Finite Automata (6,5 EC) Research project: Similarity (3,5 EC) Module 3 Project (5 EC) plus Intro to Math Modelling (1 EC)	
Quartile 8 (15 EC)	**Applied Mathematics**	**Technical Computer Science**
	Stochastic Models (5 EC) Stochastic Models Project (1,5 EC) Markov Chains (2,5 EC) Stochastic Simulation Project (4 EC) Multidisciplinary Project (2 EC)	

Third academic year: 55-65 EC

Quartile 9 (10 EC)	**Applied Mathematics**	**Technical Computer Science**
	Analysis II (5 EC) Project (3 EC) Presentation Skills (2EC)	
Quartile 10 (15 EC)	**Minor profile**	
	http://www.utwente.nl/en/education/electives/minor	
Quartile 11 (15-20 EC)	**Applied Mathematics**	**Technical Computer Science**
	one of the following four components must be included in the student's exam programme: Graph Theory (5 EC) Introduction to PDE (5 EC) Random Signals and Filtering (5 EC) Mathematical Optimization (5 EC) Reflection on Mathematical Research I (5 EC)	Design assignment (10 EC)
Quartile 12 (15-20 EC)	**Applied Mathematics**	**Technical Computer Science**
	Complex Function Theory (3 EC) Reflection on Mathematical Research II (2 EC) Bachelor's Assignment (10 EC)	