

MATHEMATICS AT THE VIENNA UNIVERSITY OF TECHNOLOGY

TU Wien offers four bachelor programs and six master programs in mathematics.

Bachelor programs.

- (1) Mathematics in Science and Technology
- (2) Mathematics in Computer Science
- (3) Statistics and Mathematics in Economics
- (4) Financial and Actuarial Mathematics

The nominal study time for a bachelor program is 6 semesters (180 ECTS points). The courses recommended for the first 2 semesters are the same for each of the 4 programs, enabling students to switch to a different program at or before the beginning of the second year. Each of the above bachelor degrees entitles a student to enroll in one of the master programs below.

Master programs.

- (1) Mathematics in Science and Technology
- (2) Mathematics in Economics
- (3) Mathematics in Computer Science
- (4) Statistics
- (5) Financial and Actuarial Mathematics
- (6) Mathematics

The nominal study time for each of these programs is 4 semesters (120 ECTS points).

TU Wien also offers a **Ph.D. program**.

BACHELOR PROGRAMS

TU Wien offers 4 mathematical bachelor programs:

- (1) **Mathematics in Science and Technology**
- (2) **Mathematics in Computer Science**
- (3) **Statistics and Mathematics in Economics**
- (4) **Financial and Actuarial Mathematics**

Types of courses.

VO: lectures

UE: exercises. VU and VL are courses in which a lecture is combined with exercises.

PR: (“Praktikum”, or “lab”) are courses where practical skills (such as programming) are exercised

SE: seminars

The bachelor curriculum distinguishes three levels of requirement:

- compulsory courses – all students have to take those
- elective courses – students have to select courses from a given list; a minimum for the sum of the ECTS points from the selected courses is prescribed.
- optional courses, to be selected from all courses offered by TU Wien or even by other universities. Again a minimum of ECTS points is prescribed.

Furthermore, a total of 9 ECTS points for optional subjects has to be obtained from courses labelled as “soft skills”. The seminar and “praktikum with bachelor thesis” count for 2+4 soft skills ECTS points. The remaining 3 points have to be obtained from courses labelled as “soft skills” on a list published by TU Wien.

MATHEMATICS IN SCIENCE AND TECHNOLOGY — BACHELOR

Table 1A: Compulsory courses, recommended to be taken in the first year 36.5 semester hours, 57 ECTS-points.

<i>1st semester</i>	
Analysis 1 (5VO+2UE)	7+4 ECTS
Linear Algebra 1 (4VO+2UE)	6+4 ECTS
<i>1st or 2nd semester</i>	
Introduction to programming (4VU)	6 ECTS
<i>2nd Semester</i>	
Applications of mathematics (3RV)	2 ECTS
Analysis 2 (4VO+2UE)	6+4 ECTS
Linear Algebra 2 (5VO+2UE)	7+4 ECTS
Introduction to probability and statistics (2VO+1.5UE)	4+3 ECTS

Table 2A: Compulsory subjects (and recommendations for when to take them) 56.5 semester hours, 78 ECTS-points

<i>2nd or 3rd semester</i>	
Computer mathematics (4VL)	6 ECTS
<i>3rd semester</i>	
Measure and probability theory (4VO+2UE)	5+3 ECTS
Numerical analysis A (4VO+2UE)	5+3 ECTS
Differential equations 1 (3.5VO+1.5UE)	4.5+2.5 ECTS
Physics (4VO+2UE)	6+3 ECTS
<i>4th semester</i>	
Analysis 3 (4VO+2UE)	5+3 ECTS
Functional analysis 1 (4VO+1UE)	5+2 ECTS
Numerics of differential equations (4VO+2UE)	5+3 ECTS
<i>5th semester</i>	
Partial differential equations (3VO+1.5UE)	4+2 ECTS
Differential geometry (3VO+1UE)	4+2 ECTS
<i>6th semester</i>	
Applied statistics (2.5VO+1.5UE)	3+2 ECTS

Table 2B: Elective courses, Mathematics in Science and Technology. 12 ECTS points have to be chosen from one of the following lists

<i>List 1: Modelling and biological science.</i>	
Modelling and simulation (2VO+2PR)	2.5+3.5 ECTS
Biophysics (2VO)	3 ECTS
Biomedical Engineering: An Introduction. (2VO)	3 ECTS
Epidemiology (2VO)	3 ECTS
Control Models in Physiology. (2VO)	3 ECTS
Brain Modeling (2VO)	3 ECTS
Visualization (2VU)	3 ECTS
<i>list 2: Electrical engineering:</i>	
Fundamentals of electronics (2VO)	3 ECTS
Electrodynamics (3VU)	4.5 ECTS
Signals and Systems 1 (3VU)	4.5 ECTS
Signals and Systems 2 (3VU)	4.5 ECTS
Wave propagation (3VU)	4.5 ECTS
<i>List 3: Physics and mechanics:</i>	
Mechanics for technical physicists. (4VO+2UE)	6+3 ECTS
Finite elasticity (2VO)	3 ECTS
Fluid Mechanics (3VO)	4 ECTS
Material science (2VO)	3 ECTS
Quantum physics (5VU)	8 ECTS
Solid state physics I (2VO)	4 ECTS
Waves in fluids (2VO)	3 ECTS
<i>List 4: Numerical analysis and scientific computing:</i>	
Introduction to Scientific Computing (3VO+1UE)	4.5+1.5 ECTS
Time dependent problems in physics and technology (3VO+1UE)	4.5+1.5 ECTS
Finite element methods (3VO+1UE)	4.5+1.5 ECTS
Iterative solution of large systems of equations (3VO+1UE)	4.5+1.5 ECTS
Visualization (2VU)	3 ECTS
Modelling and Simulation (2VO+2PR)	2.5+3.5 ECTS

Table 1B: Seminar and Lab with bachelor thesis, plus optional subjects and Soft Skills. 33 ECTS-points.

Seminar (2SE)	3 ECTS
(2 of those ECTS points count as <i>Soft Skills</i>)	
Praktikum (lab) with bachelor thesis (4PR)	12 ECTS
(4 of those ECTS points count for <i>Soft Skills</i>)	
<i>Optional subjects and Soft Skills</i>	18 ECTS

MATHEMATICS IN COMPUTER SCIENCE — BACHELOR

Table 1A: Compulsory courses, recommended to be taken in the first year 36.5 semester hours, 57 ECTS-points.

<i>1st semester</i>	
Analysis 1 (5VO+2UE)	7+4 ECTS
Linear Algebra 1 (4VO+2UE)	6+4 ECTS
<i>1st or 2nd semester</i>	
Introduction to programming (4VU)	6 ECTS
<i>2nd Semester</i>	
Applications of mathematics (3RV)	2 ECTS
Analysis 2 (4VO+2UE)	6+4 ECTS
Linear Algebra 2 (5VO+2UE)	7+4 ECTS
Introduction to probability and statistics (2VO+1.5UE)	4+3 ECTS

Table 3A: Compulsory subjects (and recommendations for when to take them) 49 semester hours, 71 ECTS-points

<i>2nd or 3rd semester</i>	
Computer math (4VL)	6 ECTS
<i>3rd Semester</i>	
Measure and probability theory (4VO+2UE)	5+3 ECTS
Introduction to computer science (2VO)	3 ECTS
Algebra (4VO+2UE)	5+3 ECTS
Applied geometry (2VO+1UE)	3+2 ECTS
<i>3rd or 4th Semester</i>	
Algorithms and data structures 1 (4VL)	6 ECTS
<i>4th Semester</i>	
Analysis 3 (4VO+2UE)	5+3 ECTS
Theoretical computer science (2VO+1UE)	3+2 ECTS
Information theory, coding theory (2VO+1UE)	3+2 ECTS
<i>5th Semester</i>	
Numerical mathematics B (3VO+2UE)	4+3 ECTS
Differential equations 1 (3.5VO+1.5UE)	4.5+2.5 ECTS
Object oriented programming (2VL)	3 ECTS

Table 3B: Elective courses in *Mathematics in Computer Science*. 19 ECTS-points

<i>19 ECTS-points from the following list:</i>	
Error correcting codes (2VO+1UE)	3+2 ECTS
Stochastic foundations of computer science (3VO+1UE)	4+2 ECTS
Logic and foundations of mathematics (2VO+1UE)	3+2 ECTS
Computer Aided Geometric Design (2VO+1UE)	3+2 ECTS
Kinematics (2VO)	3 ECTS
Number theory (2VO+1UE)	3+2 ECTS
Discrete Geometry (2VO)	3 ECTS
Algorithms and data structures 2 (2VO)	3 ECTS
Math. methods in cryptology (2VO+1UE)	3+2 ECTS

Table 1B: Seminar and Lab with bachelor thesis, plus *optional subjects and Soft Skills*. 33 ECTS-points.

Seminar (2SE)	3 ECTS
(2 of those ECTS points count as <i>Soft Skills</i>)	
Praktikum (lab) with bachelor thesis (4PR)	12 ECTS
(4 of those ECTS points count for <i>Soft Skills</i>)	
<i>Optional subjects and Soft Skills</i>	18 ECTS

STATISTICS AND MATHEMATICS IN ECONOMICS — BACHELOR

Table 1A: Compulsory courses, recommended to be taken in the first year 36.5 semester hours, 57 ECTS-points.

<i>1st semester</i>	
Analysis 1 (5VO+2UE)	7+4 ECTS
Linear Algebra 1 (4VO+2UE)	6+4 ECTS
<i>1st or 2nd semester</i>	
Introduction to programming (4VU)	6 ECTS
<i>2nd Semester</i>	
Applications of mathematics (3RV)	2 ECTS
Analysis 2 (4VO+2UE)	6+4 ECTS
Linear Algebra 2 (5VO+2UE)	7+4 ECTS
Introduction to probability and statistics (2VO+1.5UE)	4+3 ECTS

Table 4A: Compulsory subjects (and recommendations for when to take them) 45 semester hours, 65 ECTS-points.

<i>2nd or 3rd semester</i>	
Computer mathematics (4VL)	6 ECTS
<i>3rd semester</i>	
Measure and probability theory (4VO+2UE)	5+3 ECTS
Differential equations 1 (3.5VO+1.5UE)	4.5+2.5 ECTS
Principles of Economics (3VO+1UE)	4.5+2 ECTS
Computer statistics (3VL)	4.5 ECTS
<i>4th semester</i>	
Analysis 3 (4VO+2UE)	5+3 ECTS
Applied Statistics (2.5VO+1.5UE)	3+2 ECTS
<i>5th semester</i>	
Numerical analysis B (3VO+2UE)	4+3 ECTS
Basics of operations research (3VO+1UE)	4.5+2 ECTS
Basics of econometrics (3VO+1UE)	4.5+2 ECTS

Table 4B: Elective courses *Mathematics of economics*. 25 ECTS points have to be chosen from this list, or from list 4C (below)

Basics of Corporate Finance and Financial Engineering (2VU+1VU)	3+2 ECTS
Basics of Finance (2VO)	3 ECTS
Monetary economy (3VO+1UE)	5+2 ECTS
Financial investment methods and concepts (2VO)	3 ECTS
Industrial organization (2VO)	3 ECTS
Optimization in practice (3VU)	4.5 ECTS
Microeconometrics (3VO+1.5UE)	4.5+1.5 ECTS
International Trade (2VO)	3 ECTS
Statistical data collection in economy (2VO)	3 ECTS

Table 4C: Elective courses *Statistics*. 25 ECTS points have to be chosen from this list, or from list 4B (above)

Main Features of Preliminary Statistical Data Analysis (2VU)	3 ECTS
Introduction to stochastic processes and time series analysis (3VO+1UE)	4+2 ECTS
Multivariate Statistics (3VO+1UE)	5+2 ECTS
Statistical data collection in economy (2VO)	3 ECTS
Optimal statistical design (2VO+1UE)	3+1.5 ECTS
Engineering Statistics (3VO+2UE)	4+3 ECTS
Business statistics (3VU)	4.5 ECTS

Table 1B: Seminar and Lab with bachelor thesis, plus *optional subjects and Soft Skills*. 33 ECTS-points.

Seminar (2SE)	3 ECTS
(2 of those ECTS points count as <i>Soft Skills</i>)	
Praktikum (lab) with bachelor thesis (4PR)	12 ECTS
(4 of those ECTS points count for <i>Soft Skills</i>)	
<i>Optional subjects and Soft Skills</i>	18 ECTS

FINANCIAL AND ACTUARIAL MATHEMATICS — BACHELOR

Table 1A: Compulsory courses, recommended to be taken in the first year 36.5 semester hours, 57 ECTS-points.

<i>1st semester</i>	
Analysis 1 (5VO+2UE)	7+4 ECTS
Linear Algebra 1 (4VO+2UE)	6+4 ECTS
<i>1st or 2nd semester</i>	
Introduction to programming (4VU)	6 ECTS
<i>2nd Semester</i>	
Applications of mathematics (3RV)	2 ECTS
Analysis 2 (4VO+2UE)	6+4 ECTS
Linear Algebra 2 (5VO+2UE)	7+4 ECTS
Introduction to probability and statistics (2VO+1.5UE)	4+3 ECTS

Table 1B: Seminar and Lab with bachelor thesis, plus *optional subjects and Soft Skills*. 33 ECTS-points.

Seminar (2SE)	3 ECTS
(2 of those ECTS points count as <i>Soft Skills</i>)	
Praktikum (lab) with bachelor thesis (4PR)	12 ECTS
(4 of those ECTS points count for <i>Soft Skills</i>)	
<i>Optional subjects and Soft Skills</i>	18 ECTS

Table 5: Compulsory subjects (and recommendations for when to take them) 66 semester hours, 90 ECTS-points.

<i>2nd or 3rd semester</i>	
Computer mathematics (4VL)	6 ECTS
<i>3rd semester</i>	
Measure and probability theory (4VO+2UE)	5+3 ECTS
Differential equations (3.5VO+1.5UE)	4.5+2.5 ECTS
Life insurance mathematics (3VO+2UE)	4+3 ECTS
Insurance business management (2VO)	2.5 ECTS
<i>4th semester</i>	
Analysis 3 (4VO+2UE)	5+3 ECTS
Introduction to stochastic processes and time series analysis (3VO+1UE)	4+2 ECTS
Applied Statistics (2.5VO+1.5UE)	3+2 ECTS
Introduction to mathematics of Finance: discrete models (4VU)	6 ECTS
Insurance contract law (2VO)	2 ECTS
Accounting for Banking and Insurance (2VO)	2.5 ECTS
<i>5th semester</i>	
Numerical analysis B (3VO+2UE)	4+3 ECTS
Life and health insurance mathematics (3VO+2UE)	4+2.5 ECTS
Quantitative methods in risk management (3VU)	4.5 ECTS
Insurance supervision law (2VO)	2 ECTS
<i>6th semester</i>	
Non-life insurance mathematics (3VO+2UE)	4+3 ECTS
Financial Markets and Financial Intermediation (2VO)	3 ECTS

MASTER PROGRAMS

TU Wien offers 6 mathematical master programs:

- (1) **Mathematics in Science and Technology**
- (2) **Mathematics in Economics**
- (3) **Mathematics in Computer Science**
- (4) **Statistics**
- (5) **Financial and Actuarial Mathematics**
- (6) **Mathematics**

The following pages list the required courses for these programs.

Admission. Any student who has completed one of the 4 bachelor degrees in mathematics at TU Wien is admitted to any of the 6 mathematical master programs. Outside students with a bachelor's degree in mathematics are in general admitted to a master program; other bachelor degrees may also be sufficient for admission. The decision about admission rests with the vice-rector for studies at TU Wien.

Final exams and thesis. In the course of their M.A. program, students will have to write a *master's thesis*.

The final exam is taken before a committee; the exam consists of

- a “thesis defense” in which the student presents his/her M.A. thesis,
- followed by an examination on an area of mathematics connected with the thesis; this area is proposed by the student and chosen by the dean of studies.

Types of courses.

VO: lectures

UE: exercises. VU and VL are courses in which a lecture is combined with exercises.

PR: (“Praktikum”, or “lab”) are courses where practical skills (such as programming) are exercised

SE: seminars

The M.A. curriculum distinguishes four levels of requirement:

- compulsory courses – all students have to take those
- elective courses – students have to select courses from a given list; a minimum for the sum of the ECTS points from the selected courses is prescribed.
- depth requirement – a certain number of ECTS points has to be taken from one a group of courses which is divided into 9 catalogs (see page 14). 3 of those ECTS points have to come from a seminar.
- optional courses, to be selected from all courses offered by TU Wien or even by other universities. Again a minimum of ECTS points is prescribed.

Furthermore, a total of 4.5 ECTS points for optional subjects has to be obtained from courses labelled as “soft skills”.

MATHEMATICS IN SCIENCE AND TECHNOLOGY — MASTER

<i>1st Semester</i>	
Algebra (4VO+2UE)	5+3 ECTS
Functional analysis 2 (3VO+1UE)	4.5+2 ECTS
<i>2nd Semester</i>	
Stochastic analysis (3VO+1UE)	5+2 ECTS
Complex analysis (4VO+1UE)	5+2 ECTS
Calculus of variations (3VO+2UE)	4.5+3 ECTS
<i>Elective courses:</i> 12 ECTS points from the following list:	12 ECTS
Analysis on manifolds (3VO+1UE)	4.5+1.5 ECTS
Differential equations 2 (3VO+1UE)	4.5+1.5 ECTS
Finite element methods (3VO+1UE)	4.5+1.5 ECTS
Time dependent problems in physics and technology (3VO+1UE)	4.5+1.5 ECTS
<i>Depth requirement:</i>	33 ECTS
<i>Optional courses (including 4.5 ECTS points “soft skills”)</i>	9 ECTS
<i>M.A. thesis</i>	30 ECTS

The 33 ECTS points in the “depth requirement” have to be taken from catalogs I–IX on page 14; 9 of those must be from catalog V, 8 more from one of the catalogs I, II, IV, V.

One seminar labelled AKANA, AKNUM or AKANW has to be chosen.

MATHEMATICS IN ECONOMICS — MASTER

<i>1st semester</i>	
Game theoretic modeling (3VO+1UE)	5+2 ECTS
Nonlinear optimization (2VO+1UE)	3+2 ECTS
Differential equations 2 (3VO+1UE)	5+2 ECTS
<i>2nd semester</i>	
Functional analysis 1 (4VO+1UE)	5+2 ECTS
Applied Operations Research (3VO+1UE)	5+2 ECTS
Stationary processes and time series analysis (3VO+2UE)	5+3 ECTS
<i>4th semester</i>	
Introduction to mathematics of Finance: discrete models (4VU)	6 ECTS
<i>Depth requirement:</i>	34 ECTS
<i>Optional courses (including 4.5 ECTS points “soft skills”)</i>	9 ECTS
<i>M.A. thesis</i>	30 ECTS

The 34 ECTS points in the “depth requirement” have to be taken from catalogs I–IX on page 14; 17 of those must be from one of the catalogs VI, VII, IX.

MATHEMATICS IN COMPUTER SCIENCE — MASTER

Discrete methods (4VO+2UE)	6+3 ECTS
Functional analysis 1 (4VO+1UE)	5+2 ECTS
Complex Analysis (4VO+1UE)	5+2 ECTS
<i>Elective courses: 26 ECTS points from the following list:</i>	26 ECTS
Analysis of algorithms (3VO+2UE)	5+4 ECTS
Algorithmic geometry (2VO+1UE)	3+2 ECTS
Computer algebra and algebraic specification (2VO+1UE)	3+2 ECTS
Theoretical computer science (2VO+1UE)	3+2 ECTS
Geometry in Technology (2VO+1UE)	3+2 ECTS
Computer assisted differential geometry (2VO)	3 ECTS
Modeling and simulation (2VO)	2.5 ECTS
Areas of mathematical logic (3VO)	5 ECTS
<i>Depth requirement:</i>	32 ECTS
<i>Optional courses (including 4.5 ECTS points “soft skills”)</i>	9 ECTS
<i>M.A. thesis</i>	30 ECTS

The 32 ECTS points in the “depth requirement” have to be taken from catalogs I–IX on page 14; 16 of those must be from one of the catalogs II, IV, V, VIII.

FINANCIAL AND ACTUARIAL MATHEMATICS — MASTER

<i>1st semester</i>	
Stochastic analysis in financial and actuarial mathematics 1 (2VO+1UE)	4+2 ECTS
Risk theory (4VO+2UE)	6+4 ECTS
Private law (2VO)	3 ECTS
<i>2nd semester</i>	
Financial mathematics (4VO+2UE)	6+4 ECTS
Functional analysis 1 (4VO+1UE)	5+2 ECTS
Advanced life insurance mathematics (4VU)	7 ECTS
<i>3rd semester</i>	
Stochastic control theory (3VU)	5 ECTS
<i>Depth requirement:</i>	33 ECTS
<i>Optional courses (including 4.5 ECTS points “soft skills”)</i>	9 ECTS
<i>M.A. thesis</i>	30 ECTS

The 33 ECTS points in the “depth requirement” have to be taken from catalogs I–IX on page 14; 16.5 of those must be from one of the catalogs III, VI, VII, IX.

STATISTICS — MASTER

Functional analysis 1 (4VO+1UE)	5+2 ECTS
General Regression Models (2VO+1UE)	3+2 ECTS
Bayesian statistics (2VO+1UE)	3+2 ECTS
Mathematical statistics (3VO+1UE)	5+2 ECTS
Statistics seminar (2SE)	3 ECTS
Statistical simulation and computer intensive methods (2VU)	3 ECTS
Classification and Discriminant Analysis (3VU)	5 ECTS
Nonparametric methods in statistics (3VO+1UE)	5+2 ECTS
Theory of stochastic processes (3VO+2UE)	5+3 ECTS
<i>Depth requirement:</i>	31 ECTS
<i>Optional courses (including 4.5 ECTS points “soft skills”)</i>	9 ECTS
<i>M.A. thesis</i>	30 ECTS

The 31 ECTS points in the “depth requirement” have to be taken from catalogs I–IX on page 14; 15.5 of those must be from one of the catalogs III, VI, IX.

MATHEMATICS — MASTER

Algebra (4VO+2UE)	5+3 ECTS
Functional analysis 1 (4VO+1UE)	5+2 ECTS
Complex Analysis (4VO+1UE)	5+2 ECTS
Theory of stochastic processes (3VO+2UE)	5+3 ECTS
Topology (3VO+1UE)	4+2 ECTS
<i>Elective courses from “Analysis and Stochastics”</i> : 12 ECTS points from the following list	
	12 ECTS
Analysis on manifolds (3VO+1UE)	4.5+1.5 ECTS
Differential geometry (3VO+1UE)	4+2 ECTS
Functional analysis 2 (3VO+1UE)	4.5+1.5 ECTS
Mathematical statistics (3VO+1UE)	5+2 ECTS
Stochastic analysis (3VO+1UE)	4.5+1.5 ECTS
Calculus of variations (3VO+2UE)	4.5+3 ECTS
<i>Elective courses from “Discrete mathematics”</i> : 10 ECTS points from the following list	
	10 ECTS
Algebra 2 (3VO+1UE)	4.5+1.5 ECTS
Discrete methods (4VO+2UE)	6+3 ECTS
Areas of mathematical logic (3VO)	5 ECTS
Logic and foundations of mathematics (2VO+1UE)	3+1 ECTS
Number theory (2VO+1UE)	3+2 ECTS
<i>Depth requirement</i> :	23 ECTS
<i>Optional courses (including 4.5 ECTS points “soft skills”)</i>	9 ECTS
<i>M.A. thesis</i>	30 ECTS

The 23 ECTS points in the “depth requirement” have to be taken from catalogs I–IX on page 14; 11.5 of those must be from one of the catalogs I, II, III, VIII and IX.

CATALOGS FOR THE DEPTH REQUIREMENT

Each of the 9 catalogs may contain

- Specifically named courses, often from a non-mathematical curriculum: physics (TPH), chemistry (TCH), computer science (INF), business informatics (WINF), electrical engineering (ET), mechanical engineering (MB) or mechanical engineering/management (WIMB).
- Courses whose specific topics and titles may vary from year to year; these courses fit into one of the 9 catalogs if they are appropriately labelled (e.g. courses labelled as AKANA = “Ausgewählte Kapitel der Analysis” = “Selected topics in analysis” are automatically included in catalog I).

I. *Analysis.*

All courses labeled AKANA (Topics from Analysis)

II. *Algebra, discrete mathematics and geometry.*

All courses labelled AKALG, AKDIS, AKGEO (selected topics in algebra, discrete mathematics, geometry, respectively)

III. *Probability and statistics.*

All courses labelled AKWTH, AKSTA (selected topics in probability theory, statistics, respectively)

IV. *Applied and numerical mathematics.*

All courses labelled AKANW, AKNUM (selected topics in applications, numerical analysis, respectively)

V. *Mathematical modeling, simulation, applications in science and technology.*

All courses labelled AKMOD, AKSIM, AKBIO (selected topics in modeling, simulation, biology, respectively).

Also the following courses are included in this catalog:

- Mechanics for TPH (TPH) 4VO+2UE
- Electromechanics I, II (TPH) 5VU,2VO
- Quantum Mechanics I, II (TPH) 5VU,3VU
- Statistical Physics I, II (TPH) 3VU,2VO
- Solid state physics I, II (TPH) 2VO,2VO
- Material Science (TPH) 2VO
- Fluid Mechanics (TPH) 3VO
- Waves in Fluids (MB) 2VO
- Wave propagation (ET) 3VU
- Strength of materials (MB) 2VO+2UE
- Signals and Systems 2 (ET) 3VU
- Processing of Stochastic Signals (ET) 3VU
- Deterministic signal processing (ET) 3VU
- System technology in Automation (ET) 4VU
- Components of Automatization (ET) 2VO
- Control systems (ET) 3VO+3UE
- Process identification (ET) 3VU
- Atomic, nuclear and particle physics (TPH) 3VO
- Intro to Multi-body-system dynamics (MB) 2VO+1UE
- Control engineering (MB) 3VU
- Multiphase Systems (MB) 2VO+2RU
- Theoretical Chemistry (TCH) 2VO
- Solid state chemistry (TCH) 1VO+1UE
- Methods in quantum chemistry (2VO)
- Biology 2VO
- Path integrals in quantum mechanics and quantum field theory (TPH) 2VO
- Introduction into Biophysics (ET) 2VO
- Biomechanics of human locomotion (MB) 2VO
- Finite Element Methods in Biomechanics (MB) 2VU
- Applications of nuclear physics in biology and medicine (TPH) 2VO
- Signal processing in biology (INF) 3VU

– Biomedical Fluid Mechanics (MB) 2VO

– Mechanical Aspects of Biophysics. 1VU

VI. *Econometrics and Operations Research.*

All courses labelled AKOEK, AKOR (selected topics in econometrics, OR, respectively)

VII. *Economy.*

All courses labelled AKVWT, AKVWL (selected topics in economy).

Also the following courses are included in this catalog:

- Quantitative Methods (WIMB) 2VO+1UE
- Industrial Organization (WIMB) 2VO
- Marketing research (INF) 2VU
- Industrial economics and policy (WIMB) 2VO
- Strategic Marketing (WIMB) 2VO
- Strategic planning (WIMB) 1VO
- Methods in corporate finance (WIMB) 2VO
- Accounting 1, 2 (WINF,WIMB) 2VU,2VU
- Financial Markets and Financial Intermediation 2VO

VIII. *Logic, theoretical and practical computer science.*

All courses labelled AKLOG, AKTHI (selected topics in logic, theoretical computer science, respectively)

Also the following courses are included in this catalog:

- Algorithms and Data Structures 2 2VO
- Database systems 4VL
- Systems Programming 3VL
- Computer Graphics 1 2VO+2LU
- Object-oriented Programming 2VL
- Object Oriented Modeling 2VU
- Electrical Engineering for Computer Engineering 3VO+2LU
- Network Services 2VU
- Selected topics in pattern recognition 2VU
- Formal Methods in Computer Science 4VU

IX. *Financial and actuarial mathematics, insurance.*

All courses labelled AKFVM, AKVFM (selected topics in financial and actuarial mathematics)

Also the following courses (from the mathematical curriculum) are included in this catalog:

- Introduction to mathematics of Finance: discrete models 4VU
- Financial mathematics (continuous models) 4VO+2UE
- Life and health insurance mathematics 3VO+2UE
- Non life insurance mathematics 3VO+2UE
- Quantitative methods in risk management 3VU
- Risk theory 4VO+2UE
- Stochastic analysis in financial and actuarial mathematics 1 2VO+1UE
- Advanced life insurance mathematics 4VU
- Stochastic control theory 3VU

REQUIRED MINIMUM CONTENTS OF THE COURSES IN THE BACHELOR AND MASTER CURRICULA

- Accounting for Banking and Insurance:** Accounting in insurance industry, taxation of insurance companies
- Advanced life insurance mathematics:** Markov model and stochastic interest models in life insurance mathematics
- Algebra:** Fundamental algebraic structures, isomorphism theorems, finitely generated abelian groups, divisibility, polynomials and formal power series, field extensions, finite fields.
- Algebra 2:** Group actions and Sylow theorems, Galois theory, basics of commutative algebra and noncommutative ring theory.
- Algorithmic geometry:** Geometric algorithms (convex hull, Voronoi decomposition, motion planning) from the point of view of data structures, algorithmic complexity and applications
- Algorithms and data structures 1:** Fundamental algorithms and their analysis, such as e.g. sorting and searching, abstract data structures, hashing, optimization.
- Algorithms and data structures 2:** Advanced topics in algorithms and data structures (e.g., randomized algorithms, large data sets, optimization, geometric algorithms)
- Analysis 1:** Basic mathematical notions (sets, logical inference), real and complex numbers, convergence (limits, metric, compactness, etc.), functions (continuity, uniform convergence, power series), differentiation (mean value theorem, Taylor expansions, etc), elementary functions
- Analysis 2:** Riemann integral, multivariate differential calculus (extrema, inverse functions, etc.), fundamental notions from topology, approximation (Fourier series, Stone-Weierstrass)
- Analysis 3:** Merging of analysis and measure theory (Riemann integral vs. Lebesgue integral, absolutely continuous functions, etc.), integral transforms (Fourier and Laplace transforms), change of variables formulas, theorems of Gauss-Green, Stokes
- Analysis of algorithms:** Applications of discrete methods to concrete algorithms (e.g. quicksort)
- Analysis on manifolds:** Smooth Manifolds and maps, vector fields, flow, integration and differential forms, selected topics (Lie groups, fixed point methods, etc)
- Application areas of mathematics:** Presentation of the contents of the bachelor and master programs
- Applied Geometry:** Fundamentals of geometry (curves, surface, motion), methods and algorithms of geometric data processing
- Applied operations research:** Modelling of statistical and dynamic optimization problems, solution with (non)linear/dynamic programming, optimal control theory etc, (economic) interpretation, sensitivity analysis
- Applied statistics:** Basic notions of parametric and nonparametric methods, linear models, variance analysis, multiple regression, Bayes methods, estimates and tests, computer-based exercises
- Areas of mathematical logic:** Model theory, set theory, recursion theory, proof theory.
- Basics of econometrics:** Basic empirical analysis of economic theories, methods of regression analysis, multivariate regression, identification
- Basics of operations research:** Model formation and phases of an OR study, linear programming (simplex algorithm, duality, economic interpretation), numerical methods for solving nonlinear optimization problems.
- Bayesian statistics:** Fundamentals of Bayesian statistics, conjugate models, Bayes decisions, nonparametric methods
- Biomedical Engineering: An Introduction:** Survey of several areas in which courses are offered at TU Wien
- Biophysics:** Survey of applied biophysics
- Brain modeling:** Models and simulation of neural structures, understanding the natural processes and methods in neuroprosthetics
- Business Statistics:** Market segmentation, evaluation of opinion polls, analysis of competition and market baskets.
- Calculus of variations:** Euler-Lagrange equations, direct method of variational calculus (solution theory), variational problems with constraints, variational inequalities
- Classification and Discriminant Analysis:** Basics of linear models, flexible classification and regression methods, model selection and evaluation, model discrimination
- Complex analysis:** Holomorphic functions (complex differentiation, power series etc), fundamental theorems of complex analysis (Cauchy's integral theorem, residue theorem), conformal maps (Riemann's mapping theorem), analytic continuation; selected topics (e.g. Factorization, growth, harmonic functions, elliptic functions)
- Computer Aided Geometric Design:** Algorithms, properties and applications of spline spaces and other function spaces, geometric methods in computer graphics such as e.g. subdivision algorithms
- Computer algebra and algebraic specification:** Basics of algebraic specification, computer algebra (Gröbner bases)
- Computer assisted differential geometry:** Algorithms and discrete methods with the aim of discretizing classical differential geometry (e.g. discrete minimal surfaces, discrete differential equations), numerical and statistical methods
- Computer mathematics:** Software tools and packages for: numerical linear algebra, computer algebra, statics; word processing and typesetting in science
- Computer statistics:** Exploration and analysis of statistical data, computer based methods, use of special software, in particular new developments. Working with large examples. Methods include: descriptive statistics, comparison of groups of data, variance analysis, regression analysis, geostatistics, simulation
- Differential equations 1:** Ordinary differential equations: existence theory, equations with elementary solutions, linear equations and systems of equations, boundary value problems, introduction to partial differential equations (method of characteristics for first order equations, wave equation, heat equation)
- Differential equations 2:** Advanced topics from the area of ODEs: nonlinear dynamics, stability, qualitative and geometric methods, bifurcation theory, perturbation methods, systems with special structure

- Differential geometry:** Curves and surfaces in Euclidean space, examples of variation problems, local and global methods in Riemannian geometry, integration, integration theorems
- Discrete geometry:** Polytopes, lattices, packing, covers
- Discrete methods:** Linear recursions, basic combinatorial problems, generating functions, combinatorics on partial orders, Polya counting theory, graph theory, algorithms on networks
- Electrodynamics:** theoretical foundations of classical electrodynamics and special relativity
- Electrodynamics:** Maxwell's field equations, stationary and dynamical fields, waves
- Engineering Statistics:** Quality control, reliability analysis, graphical methods
- Epidemiology:** Basic deterministic and stochastic models for disease propagation, models
- Error correcting codes:** Linear codes, algebraic and geometric methods for generation and analysis of error correcting codes, bounds for the parameters, BCH codes and other classes of examples
- Financial Markets and Financial Intermediation:** Function of banks, functions of the central bank, functions and organization of the stock exchange, order processing, stability of financial system, financial market authority, supervision of securities, bank supervision, Basel II
- Financial mathematics:** Stochastic theory of finance markets, notion of arbitrage, equivalent martingale measures
- Finite Elements Methods:** Elliptic boundary value problems and variational formulations, Galerkin method, convergence analysis and algorithmic realization of the finite element method
- Fluid Mechanics:** Basic equations, frictionless flows, vortices, lift, drag, compressional shock, fluid laws, Navier-Stokes equations, dimensional analysis, laminar and turbulent flows, boundary layers
- Functional analysis 1:** Locally convex vector spaces, Hahn-Banach theorem, Banach- and Hilbert spaces, Fourier series, theorems of Baire, Banach-Steinhaus, open mapping theorem, closed range theorem, spectral theory, spectral theorem for compact, self-adjoint operators
- Functional analysis 2:** Spectral theorem for unbounded self-adjoint operators, strongly continuous semigroups, selected topics in nonlinear functional analysis
- Fundamentals of electronics:** Fundamentals of simple electronic devices and circuits
- Game Theoretic Modeling:** Nash equilibrium and refinements, evolutionary game theory, differential games, auction theory
- General Regression Models:** Simple linear regression, residual analysis, selection methods, generalized linear models, nonparametric regression, nonlinear regression, robust regression
- Geometry in Technology:** Geometric methods for industrial and technical problems. Emphasis on: optimization, large data sets, image processing, kinematic registration algorithms
- Information- and Coding Theory:** Entropy, Source Coding, Information Sources (Markov-chains, Stationary processes), Data Compression Methods
- Insurance business management:** Forms of insurance, Supervision, Organization of insurance companies, Investments.
- Insurance contract law:** Basis of insurance contract law
- Insurance supervision law:** Supervision law, European framework, investment, solvency requirements.
- International Trade:** Labor Productivity and Comparative Advantage: The Ricardian Model, Income Distribution, Resources and Trade, Economies of Scale, Imperfect Competition, Trade Policy
- Introduction to Computer Science for mathematicians:** Basics of computer architectures, operating systems and networks, elements of scientific computing
- Introduction to mathematics of Finance: discrete models:** Time discrete or finite probability space. Modelling of finance markets, arbitrage, portfolio optimization, binomial model, introduction to the theory of incomplete markets
- Introduction to probability and statistics:** Descriptive statistics, elementary probability theory, the notion of randomness, one- and multidimensional discrete and continuous random variables, conditional distribution, sequences of random variables, simple inferential statistics
- Introduction to Programming:** Basic programming techniques, realization of algorithms in a programming language, simple algorithms related to the material of the courses "analysis" and "linear algebra", elements of object oriented programming
- Introduction to Scientific Computing:** The path from the physical model to its simulation, computing on modern computer architectures, complexity, fast iterative and recursive algorithms, Monte-Carlo methods
- Introduction to stochastic processes and time series analysis:** Basics of stochastic processes and important examples (among others: Markov chains, martingales, Brownian motion), methods in time series analysis
- Iterative solution of large systems of equations:** Classical iterative methods, conjugate gradient method, GMRES, preconditioning, multigrid,
- Kinematics:** Analysis of rigid body motion, differentiable groups, subgroups, mechanisms, applications to robotics and computer graphics
- Life and health insurance mathematics:** Markov's life insurance model in discrete time, reserves, mathematics of health insurance
- Life insurance mathematics:** Interest, life tables, life insurance, life annuities, premium calculation, premium reserves,
- Linear algebra 1:** Vector spaces, linear and affine maps, dual space, determinants, systems of linear equations, geometric visualization
- Linear algebra 2:** Eigenvalues, Jordan normal form, bilinear forms, Euclidean vector spaces, normal maps, spectral theorem, fundamentals of numerical mathematics (e.g. singular value decomposition, QR decomposition), geometric visualization

- Logic and foundations of mathematics:** Predicate logic, completeness theorem, introduction to computational logic, axiom of choice, cardinality
- Main Features of Preliminary Statistical Data Analysis:** Descriptive statistics, explorative data analysis, analysis of fuzzy data
- Material sciences:** Physical foundations, crystal structures, structure determination
- Mathematical methods in cryptology:** Number theoretic foundations, cryptography, cryptanalysis
- Mathematics of control in medicine:** Models for medical and physiological systems, basics of mathematics of control, e.g. circulatory system
- Mathematics statistics:** Mathematical theory of statistical methods, estimation theory, test theory, decision theory, asymptotics of statistical experiments
- Measure and probability theory:** Measure- and Probability spaces, Lebesgue Integration, Radon-Nikodym Theorem, Fubini Theorem, Conditional Expectation, Laws of Large Numbers, Central Limit Theorem
- Mechanics for technical physicists:** Kinematics of point masses, rigid bodies and the continuum. Forces, mass geometry and dynamics of rigid and deformable bodies (strength of materials). Equations of Lagrange and Hamilton with applications to oscillations. Introduction into analytical mechanics.
- Modelling and simulation:** Methods for continuous and discrete simulation, algorithms for analyzing models, applications
- Monetary Economics:** Definition of money, function of money, money demand and supply, inflation, phillips curve, seignorage, targets of central banks, instruments of monetary policy
- Multivariate statistics:** Estimates and tests for multivariate models, model selection, diagnostics, graphics, Bayesian approaches
- Non-life insurance mathematics:** Counting processes, claim size distributions, total claim amount, reinsurance, experience rating, reserving for late claims
- Nonlinear optimization:** Translation of decision problems to a model of nonlinear optimization, theoretical basis, solution methods, ability to apply nonlinear programming in particular to problems from economy
- Number Theory:** Euclidean algorithm, prime numbers, congruences, quadratic remainder, number theoretic functions, Diophantine equations, continued fractions
- Numerical Analysis A:** Floating point arithmetic, stability and condition, interpolation and approximation, numerical quadrature, iterative methods for linear and nonlinear equations, topics in numerical linear algebra, software tools for numerical computations, numerical treatment of eigenvalue problems
- Numerical Analysis B:** Floating point arithmetic, stability and condition, interpolation and approximation, numerical quadrature, iterative methods for linear and nonlinear equations, topics in numerical linear algebra, software tools for numerical computations
- Numerics of differential equations:** Initial and boundary value problems for ordinary and partial differential equations: one step and multistep methods, finite difference methods, adaptivity
- Object oriented programming:** Basics of object oriented programming: Hierarchies, polymorphism, inheritance, etc
- Optimal statistical design:** Planning of sample size, experimental designs for recognizing and eliminating unwanted influences, optimal design for estimations in the regression model, design for model selection, applications
- Optimization in practice:** Modelling languages (such as GAMS, AMPL, ILOG), algorithms, global optimization and metaheuristics, case studies
- Partial differential equations:** Linear partial differential equations of order 1 and 2, boundary and initial value problems, eigenfunction expansion, distributions, weak formulation
- Physics:** Introduction to the basic fields of physics
- Praktikum (Lab) with bachelor thesis:** Independent work on a topic of pure or applied mathematics
- Principles of Economics:** Microeconomics: demand, production and supply, price formation; macroeconomics: measures of national income and output, macro-economic basic models (IS-LM, AS-AD etc.)
- Private law:** Basics of private law, commercial law, basics of corporations law
- Quantitative methods in risk management:** Options, risk measures, credit risk models, Black-Scholes model
- Quantum theory:** Theoretical basis of quantum theory
- Reinsurance:** Introduction to Reinsurance, reinsurance market, reinsurance models
- Risk theory:** Estimate of ruin probabilities, Lundberg inequality, distribution approximations, risk measures, utility
- Seminar:** Independent work on a topic from pure or applied mathematics, presentation of results
- Signals and systems 1:** Time continuous signals and systems, Fourier and Laplace transformation
- Signals and systems 2:** Discrete systems: basics of digital signal processing, digital LTI systems, (discrete) Fourier and Z transformation, digital filters, basics of DSPs
- Solid state physics:** Physical models for properties of solids
- Stationary processes and time series analysis:** Stationary processes in time and frequency, AR(X) and ARMAX(X) systems: solutions and identifiability, prognosis and filtering, estimation of expected value and covariance in stationary processes, estimation of parameters in AR(X) and ARMAX(X) systems
- Statistical Simulation and Computerintensive Methods:** Statistical simulation, Monte Carlo methods, bootstrap, jackknife, robust methods, Markov chain Monte Carlo methods
- Statistics seminar:** Various current topics from an area of statistics
- Stochastic analysis in financial and actuarial mathematics 1:** Itô integration, Girsanov's theorem, Black Scholes theory, valuation and hedging of derivatives in markets with one stock, Greeks

- Stochastic analysis:** Itô Integral, stochastic partial differential equations, locally invariant sub-manifolds, term structure models,
- Stochastic control theory:** diffusion processes, Hamilton-Jacobi-Bellman theory, singular control problems, applications of control theory in financial and actuarial mathematics
- Stochastic Foundations of Computer Science:** Information Channels, Channel Capacity, Channel Coding Theorem, Estimating the Entropy of Languages, Random Number Generation, Tests of Randomness, Stochastic Simulation, Monte-Carlo-Methods, Random Sampling Methods
- Theoretical Computer Science:** Introduction to recursion theory, complexity theory (e.g. NP-completeness), formal verification, automata and formal languages.
- Theory of stochastic processes:** General theory, existence of stochastic processes, adapted processes, halting times, martingales with discrete and continuous time, Markov processes, Brownian motion, Poisson Process, stochastic integral, basic notions from stochastic differential equations.
- Time dependent problems in physics and technology:** Modeling of selected in stationary problems, evolution equations, numerical solution to equations with special structure
- Topology:** Metrisability, uniform spaces, filters, topological groups, elements of algebraic topology.
- Visualization:** Visualization of mathematical concepts, emphasizing geometry and analysis. Software
- Wave propagation:** Propagation of electromagnetic waves, technical emphasis (e.g. mobile communication.)
- Waves in Fluids:** Mathematical modeling of wave propagation in fluid mechanics