

Applied Mathematics: Modelling and Data Analysis

Profile for Master of Science in Mathematics

Institute for Mathematics, University of Potsdam

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1 Overview

The main goal of this profile is for the student to gain theoretical knowledge and practical experience with mathematical modelling, simulation, data assimilation and data analysis, in an interdisciplinary setting. The student will be expected to acquire the following:

- Knowledge of fundamental mathematical concepts, models, and techniques;
- The ability to formulate and communicate scientific hypotheses in mathematical terms;
- The ability to analyse and solve problems using mathematical theory, simulation, and data analysis.

2 General requirements of the Master's program in mathematics

1. The student must complete MATVMD861: **Academic Reading and Writing** (6).
2. The student must complete **54 LP in lecture courses** from at least three of the four fields below¹. At least two fields must have 15 LP each. (1 LP = 1 credit point)
 - F1: Algebra, discrete mathematics, geometry (MATVMD811-816, 911-912)
 - F2: Analysis and Mathematical Physics (MATVMD821-828, 921-922)
 - F3: Probability Theory and Statistics (MATVMD831-838, 931-932)
 - F4: Applied Mathematics and Numerics (MATVMD841-844, 941-942; MAT-MBIP05)

Below are examples of valid and invalid choices for allocating 54 LP to the different fields.

- Valid: The student completes 15 LP in F2, 15 LP in F3, and 24 LP in F4.
- Valid: The student completes 27 LP in F2, 18 LP in F3, and 9 LP in F4.

¹For courses beginning with the 'MATVMD' code, the second-last digit after 'MATVMD' indicates which field the course belongs to. For example, MATVMD832 belongs to F3, MATVMD1041 belongs to F4, etc.

- Invalid: The student completes exactly 27 LP in F2 and 27 LP in F3.
 - Invalid: The student completes exactly 9 LP in F2, 9 LP in F3, and 36 LP in F4.
3. The student must complete **12 LP in seminar courses** from the following fields below.
- F1: Algebra, discrete mathematics, geometry (MATVMD1011-1012)
 - F2: Analysis and Mathematical Physics (MATVMD1021-1022)
 - F3: Probability Theory and Statistics (MATVMD1031-1032)
 - F4: Applied Mathematics and Numerics (MATVMD1041-1042)
4. The student must complete **18 LP from a supplementary subject**. The valid supplementary subjects are: computer science, physics, economics, business administration, cognitive sciences, life sciences with a concentration on animal physiology, and life sciences with a concentration on bioinformatics.
- The student may choose Mathematics as their supplementary subject. In this case, the student would select modules from the Mathematics courses adding up to 18 LPs, provided that these modules were not already selected for the lecture requirement or seminar requirements described above.
5. The student must write and defend their **master's thesis**. This is worth 30 LP.

3 Structure of the Profile

3.1 Requirements of the profile

The profile *Applied Mathematics: Modelling and Data Analysis* has the following additional requirements:

6. The student **must complete at least 27 LP from the following list of modules**:
- F2: MATVMD822, 826, 922, 1022
 - F3: MATVMD832, 834, 835, 837, 932, 1032
 - F4: MATVMD842, 844, 838, 942, 1042; MAT-MBIP05

See §3.2 for more details.

7. The student must write their Master's thesis in the focus area *Applied Mathematics: Modelling and Data Analysis*. The supervisor of the Master's thesis will decide whether the Master's thesis belongs to this focus area. The student should discuss this issue with the supervisor **before** beginning the master's thesis.

3.2 Foundational lecture courses

The student is strongly recommended to complete the following modules.

Courses with a '*' are described in §4.

- MATVMD844*: Survey of interdisciplinary mathematics (Winter, 9 LP).
- At least two of the following:
 - MATVMD824: Partial differential equations I (Winter, 9 LP)
 - MATVMD826: Functional analysis I (Winter, 9 LP)
 - MATVMD834*: Stochastic processes (Summer, 9 LP)
 - MATVMD837*: Statistical data analysis (Winter, 9 LP)
 - MATVMD838*: Bayesian inference and data assimilation (Summer, 9 LP)
 - MATVMD841*: Numerical optimisation (Winter, 9 LP)

Availability: In general, the courses above will be offered once per year.

Previous coursework: If the student has completed courses in their bachelor's studies that are equivalent to two of the courses above, then they should take either

- (i) two other courses from the list, or
- (ii) the 'II' versions, if these courses are available. For example, if the student has taken Partial differential equations I, then they should take Partial differential equations II.

3.3 Elective courses

The student is recommended to complete 27 LP from the following courses. Unless specified below, each course may be worth either 6 LP or 9 LP and may be offered in Winter or Summer.

- MATVMD821, 822, 921, 922: Advanced topics in analysis and mathematical physics I, II
- MATVMD835: Stochastic analysis (9 LP, offered every two years);
MATVMD831, 832, 931, 932: Advanced topics in probability theory and statistics I, II
The following topics may be offered as advanced topics in probability theory and statistics: mathematics of machine learning, Gaussian processes, nonparametric statistics
- MATMBIP05: Introduction to theoretical systems biology (Summer, 6 LP);
MATVMD841, 842, 941, 942: Advanced topics in applied math. and numerics I, II
The following topics may be offered as advanced topics in applied math. and numerics: reinforcement learning, financial mathematics, numerics of PDEs

Availability: In general, some topics mentioned above might not be offered every year. The student should check what advanced topics courses are offered every semester.

3.4 Seminars

The student is strongly recommended to take at least one seminar course in F2, F3, or F4 (see item 3. in §2) and to use the seminars to identify potential supervisors and topics for their master's thesis.

4 Overview of foundational courses

This section gives descriptions of some foundational courses that are very relevant for this profile.

MATVMD844: Survey of interdisciplinary mathematics

This course will present three selected research topics where mathematics plays an important role. The topics or application areas may change from year to year.

MATVMD834: Stochastic processes

- Markov chains
- Infinitesimal generators and master equations
- Convergence to equilibrium and reversibility
- Examples: Random walks, birth-death processes, branching processes, Poisson processes

MATVMD837: Statistical data analysis

- Multiple linear regression, logistic regression
- Statistical tests
- Analysis of variance (ANOVA)
- Nonparametric density estimation

MATVMD838: Bayesian inference and data assimilation

- Sampling algorithms, data assimilation algorithms
- Discrete time dynamical systems
- Probabilistic forecasting and ensemble prediction
- Bayesian inference

MATVMD841: Numerical optimisation

- Line Search methods
- Gradient descent and Newton methods
- Trust region methods, Quasi-Newton methods
- Constrained optimisation and Lagrange multipliers

5 Examples of study plans

Below are examples of study plans. Other study plans are possible.

A number in parentheses indicates the number of LPs for that course.

The symbol '*' indicates a foundational course (see §3.2).

The student is advised to discuss their study plan with their mentor before taking courses.

Start in winter semester

1. Semester	2. Semester	3. Semester	4. Semester
MATVMD844* Surv. Interdisc. Math. (9)	MATVMD834* Stoch. proc. (9)	MATVMD842 (9)	Master's thesis
MATVMD837* Stat. data analysis (9)	MATVMD841 Adv. topics I (9)	MATVMD822 (9)	
Supplementary subject (6)	Supplementary subject (6)	Supplementary subject (6)	
MATVMD861 Acad. reading & writing (6)	MATVMD1041 (6)	MATVMD1042 (6)	
30 LP	30 LP	30 LP	30 LP

Start in summer semester

1. Semester	2. Semester	3. Semester	4. Semester
MATVMD838* Bayes. inf. & DA (9)	MATVMD844* Surv. Interdisc. Math. (9)	MATVMD822 Adv. topics II (9)	Master's thesis
MATVMD831 Adv. topics I (9)	MATVMD837* Stat. data analysis (9)	MATVMD832 Adv. topics II (9)	
Supplementary subject (9)	Supplementary subject (9)	MATVMD1041 (6)	
	MATVMD861 Acad. reading & writing (6)	MATVMD1031 (6)	
27 LP	33 LP	30 LP	30 LP

6 Contact people for this profile

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Please find the contact information by searching the Institute directory <https://www.math.uni-potsdam.de/institut/personen>.