**Module Description, available in: EN**

# *Analysis of Sequential Data*

## General Information

**Number of ECTS Credits**

3

**Module code**

TSM_AnSeqDa

**Valid for academic year**

2026-27

**Last modification**

2023-11-12

**Coordinator of the module**

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**Explanations regarding the language definitions for each location:**

- Instruction is given in the language specified for each location and module execution.
- Documentation is available in the language(s) listed for each location and module execution. If the documentation is in multiple languages, the percentage distributed is indicated (100% = all documentation provided).
- The examination, including both questions and answers, is provided entirely (100%) in the language(s) specified for each location and module execution. The exams are on-site.

| | Lausanne | | | Lugano | Zurich | | |
|---|---|---|---|---|---|---|---|
| **Instruction** | **X** E 100% | | | | | | |
| **Documentation** | **X** E 100% | | | | | | |
| **Examination** | **X** E 100% | | | | | | |

**Module Category**

TSM Technical scientific module

**Profile Recommendations**

This module is recommended for the following profiles:

| | Lausanne |
|---|---|
| **Profile** | DS |

**Lessons**

2 lecture periods and 1 tutorial period per week

## Entry level competences

**Prerequisites, previous knowledge**

- Basic knowledge in statistics.
- Programming with scripting languages.

## Brief course description of module objectives and content

- This course provides a comprehensive introduction to time series analysis, covering both classical statistical methods and modern machine learning approaches. Starting with foundational concepts in probability and stationarity, students learn to model temporal dependencies through autocorrelation structures and classical models (MA, AR, ARMA, ARIMA, SARIMA). The curriculum progresses to practical forecasting techniques including smoothing and regression methods, volatility modeling for financial applications (ARCH/GARCH), and frequency-domain analysis through spectral methods. Advanced topics include Kalman filtering for recursive state estimation and deep learning architectures for time series. The course emphasizes both theoretical understanding and practical applications across domains such as finance, economics, and signal processing.
- The labs are done using Python

## Aims, content, methods

### Learning objectives and competencies to be acquired

**Theoretical Understanding**:
- Understand fundamental concepts of time series analysis including stationarity, autocorrelation, and temporal dependence structures
- Master classical time series models (MA, AR, ARMA, ARIMA, SARIMA) and their mathematical foundations
- Comprehend volatility modeling frameworks (ARCH/GARCH) and their applications in financial contexts
- Grasp frequency-domain analysis through spectral methods and Fourier transforms
- Understand state-space models and recursive filtering through Kalman filtering theory

**Practical Skills**:
- Identify and characterize temporal patterns in real-world data using autocorrelation and partial autocorrelation functions
- Select, estimate, and validate appropriate time series models for different data characteristics
- Apply smoothing techniques and build forecasting models using both classical and regression-based approaches
- Implement volatility models for financial risk assessment and market analysis
- Utilize spectral analysis tools to detect periodic components and frequency patterns
- Apply Kalman filtering for prediction and correction in dynamic systems
- Leverage deep learning architectures for complex time series prediction tasks

**Applied Competencies**:
- Conduct end-to-end time series analysis projects from data exploration to model deployment
- Critically evaluate model performance and select appropriate methods based on data properties and objectives
- Interpret and communicate analysis results to technical and non-technical audiences
- Apply learned techniques across various domains including finance, economics, engineering, and data science

### Module content with weighting of different components

- Getting Started: overview of time series data, objectives of analysis, and course organization.
- Basic Statistics and Probability (review): random variables, expectations, correlations, stationarity.
- Correlations and MA Processes: autocorrelation, partial autocorrelation, and moving average models.
- AR, ARMA, ARIMA, SARIMA Processes: autoregressive structures, seasonal extensions, model selection.
- Smoothing, Prediction, and Regression: moving averages, exponential smoothing, linear and nonlinear regression approaches.
- Volatility Models: ARCH, GARCH, and extensions; applications in financial time series.
- Spectral Analysis: Fourier methods, frequency-domain approaches, and applications.
- Kalman Filtering: Recursive structure: prediction and correction, interpretation.
- Deep Learning for Time Series and selected topics.

### Teaching and learning methods

- Lectures (pdfs)
- Problem Sets & Solutions
- Labs (Jupyter Notebooks)
- Project (Python)

### Literature

Slides will be available covering the topics of the course.

In addition, recommended books are:
- R.H.Shumway and D.S. Stoffer, Time Series Analysis and Its Applications, Springer 2017
- François Chollet, Deep Learning with Python, 3rd edition, Manning Publications Co., 2025 (https://www.manning.com/books/deep-learning-with-python)
- R. Hyndman and G. Athanasopoulos., Forecasting: Principles and Practice, Springer, 2018 (online free textbook at https://otexts.com/fpppy/, 2025 version)

## Assessment

### Additional performance assessment during the semester

The module contains additional performance assessment(s) during the semester. The achieved mark of the additional performance assessment(s) applies to both the regular and the resit exam.

### Description of additional performance assessment during the semester

The students will be required to do a small project which will determine 20% of the final grade.

### Basic principle for exams

**As a rule, all standard final exams are conducted in written form. For resit exams, lecturers will communicate the exam format (written/oral) together with the exam schedule.**

### Standard final exam for a module and written resit exam

**Kind of exam**

Written exam

**Duration of exam**

120 minutes

**Permissible aids**

*Aids permitted as specified below:*

**Permissible electronic aids**

Scientific calculator

**Other permissible aids**

2 Handwritten summary sheets

**Exception: In case of an electronic Moodle exam, adjustments to the permissible aids may occur. Lecturers will announce the final permissible aids prior to the exam session.**

### Special case: Resit exam as oral exam

**Kind of exam**

Oral exam

**Duration of exam**

30 minutes

**Permissible aids**

No aids permitted