

Module Handbook (<https://modhb.uni-kl.de/>)

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## Module MAT-70-11-M-4

Functional Analysis (M, 9.0 LP)

### Module Identification

Module Number	Module Name	CP (Effort)
MAT-70-11-M-4	Functional Analysis	9.0 CP (270 h)

### Basedata

CP, Effort	9.0 CP = 270 h
Position of the semester	1 Sem. in SuSe
Level	[4] Bachelor (Specialization)
Language	[EN] English
Module Manager	Grothaus, Martin, Prof. Dr. (PROF   DEPT: MAT) (/staff/15/)
Lecturers	Grothaus, Martin, Prof. Dr. (PROF   DEPT: MAT) (/staff/15/) Hussein, Amru, Jun. Prof. Dr. (PROF   DEPT: MAT) (/staff/356/) Ritter, Klaus, Prof. Dr. (PROF   DEPT: MAT) (/staff/29/)
Area of study	[MAT-SPAS] Analysis and Stochastics
Reference course of study	[MAT-88.105-SG] M.Sc. Mathematics (/mhb/FB-MAT/cos-538/)
Lifecycle-State	[NORM] Active

#### Notice

Without a proof of successful participation in the exercise classes, only 6 credit points will be awarded for the module.

### Courses

Type/SWS	Course Number	Choice in Module-Part	SL	PL	CP	Sem.
4V+2U	MAT-70-11-K-4 (/mhb/courses/MAT-70-11-K-4/)	P	U-Schein	PL1	9.0	SuSe

- About [MAT-70-11-K-4]: Title: "Functional Analysis"; Presence-Time: 84 h; Self-Study: 186 h
- About [MAT-70-11-K-4]: The study achievement [U-Schein] proof of successful participation in the exercise classes

(ungraded) must be obtained.

## Examination achievement PL1

- Form of examination: **oral examination (20-30 Min.)**
- Examination Frequency: each semester
- Examination number: 84210 ("Functional Analysis")

## Evaluation of grades

The grade of the module examination is also the module grade.

### Contents

From [MAT-70-11-K-4] **Functional Analysis** (/mhb/courses/MAT-70-11-K-4/):

- Hahn-Banach theorem and its applications,
- Baire category theorem and its applications (uniform boundedness principle, Banach-Steinhaus-Theorem, open mapping theorem, inverse mapping theorem, closed graph theorem),
- Weak convergence (Banach-Alaoglu theorem, reflexive Banach spaces, Mazur lemma and its applications),
- Projections (closed complement theorem),
- Bounded operators (adjoint operator, spectrum, resolvent, normal operators),
- Compact operators (Fredholm operators, Fredholm alternative and its applications, spectral theorem(Riesz-Schauder) and its application to normal operators),
- Unbounded operators (graph, symmetric and self-adjoint operators).

### Competencies / intended learning achievements

Upon completion of this module, the students have studied and understand the mathematical concepts of infinite-dimensional spaces with a special emphasis on the analytical aspects. They have gained the basic analytical tools required for solving differential and integral equations in theory and application. They are able to name and to prove the essential statements of the lecture as well as to classify and to explain the connections.

By completing exercises, the students have developed a skilled, precise and independent handling of the terms, propositions and techniques taught in the lecture. In addition, they have learnt how to apply these techniques to new problems, analyze them and develop solution strategies.

### Literature

From [MAT-70-11-K-4] **Functional Analysis** (/mhb/courses/MAT-70-11-K-4/):

- H.-W. Alt: Lineare Funktionalanalysis,
- H. Heuser: Funktionalanalysis,
- M. Reed, M, B. Simon: Functional Analysis I,
- D. Werner: Funktionalanalysis.

### Registration

Registration for the exercise classes via the online administration system URM (<https://urm.mathematik.uni-kl.de>) (<https://urm.mathematik.uni-kl.de>).

### Requirements for attendance (informal)

#### Modules:

- [MAT-10-1-M-2] Fundamentals of Mathematics (M, 28.0 LP) (/mhb/modules/MAT-10-1-M-2/)

#### Courses

- [MAT-12-23-K-3] Introduction to Functional Analysis (2V+1U, 4.5 LP) (/mhb/courses/MAT-12-23-K-3/)

- [MAT-12-28-K-3] Measure and Integration Theory (2V+1U, 4.5 LP) (/mhb/courses/MAT-12-28-K-3/)

### Requirements for attendance (formal)

None

### References to Module / Module Number [MAT-70-11-M-4]

Course of Study	Section	Choice/Obligation
[MAT-88.B84-SG] M.Sc. Actuarial and Financial Mathematics (/mhb/FB-MAT/cos-579/)	Statistics and Computational Methods	[WP] Compulsory Elective
[MAT-88.105-SG] M.Sc. Mathematics (/mhb/FB-MAT/cos-538/)	Pure Mathematics	[WP] Compulsory Elective
[MAT-88.105-SG] M.Sc. Mathematics (/mhb/FB-MAT/cos-538/)	Applied Mathematics	[WP] Compulsory Elective
[MAT-88.706-SG] M.Sc. Mathematics International (/mhb/FB-MAT/cos-553/)	Pure Mathematics	[WP] Compulsory Elective
[MAT-88.706-SG] M.Sc. Mathematics International (/mhb/FB-MAT/cos-553/)	Applied Mathematics	[WP] Compulsory Elective
[MAT-88.118-SG] M.Sc. Industrial Mathematics (/mhb/FB-MAT/cos-539/)	General Mathematics	[WP] Compulsory Elective
[MAT-88.276-SG] M.Sc. Business Mathematics (/mhb/FB-MAT/cos-548/)	General Mathematics	[WP] Compulsory Elective