# MODULE HANDBOOK

## Math Fundamentals (IU)

Online Certificate Math Fundamentals (UPS-DPMF)

**n/a ECTS**

**Distance Learning**

INTERNATIONAL
UNIVERSITY OF
APPLIED SCIENCES

Classification: Diploma

# Contents

# 1. Semester

# Mathematics: Analysis

**Module Code: DLBDSMFC**

| Module Type | Admission Requirements | Study Level | CP | Student Workload |
|---|---|---|---|---|
| see curriculum | none | BA | n/a | 150 h |

| Semester / Term | Duration | Regularly offered in | Language of Instruction |
|---|---|---|---|
| see curriculum | Minimum 1 semester | WiSe/SoSe | English |

**Module Coordinator**

Prof. Dr. Robert Graf (Mathematics: Analysis)

**Contributing Courses to Module**

- Mathematics: Analysis (DLBDSMFC01)

**Module Exam Type**

| Module Exam | Split Exam |
|---|---|
| Study Format: Distance Learning<br>Exam, 90 Minutes | |

**Weight of Module**

see curriculum

**Module Contents**

- Sequences and series
- Functions & reverse functions
- differential calculus
- integral calculus

**Learning Outcomes**

**Mathematics: Analysis**

On successful completion, students will be able to

- summarize the basic concepts of analysis.
- illustrate the terms "consequences" and "series".
- explain the concept of function and to understand the concept of the inverse function.
- explain basic statements of the differential and integral calculus.
- explain the relationship between differentiation and integration.
- master the derivation of higher-dimensional functions.

| **Links to other Modules within the Study Program** | **Links to other Study Programs of IU International University of Applied Sciences** |
|---|---|
| This module is similar to other modules in the field of Methods | All Bachelor Programmes in the IT & Technology fields |

# Mathematics: Analysis

**Course Code: DLBDSMFC01**

| Study Level | Language of Instruction | Contact Hours | CP | Admission Requirements |
|---|---|---|---|---|
| BA | English | | n/a | none |

**Course Description**

Analysis is one of the essential basic subjects of mathematics. Originally developed to be able to formulate and solve problems of classical mechanics mathematically, in its present rigorous form it has become indispensable in numerous applications in the natural sciences and technology. This module aims to introduce the basic hand tool of differential and integral calculus and to explain their mutual interrelations. In addition, the differential calculus is generalized to multidimensional spaces.

**Course Outcomes**

On successful completion, students will be able to

- summarize the basic concepts of analysis.
- illustrate the terms "consequences" and "series".
- explain the concept of function and to understand the concept of the inverse function.
- explain basic statements of the differential and integral calculus.
- explain the relationship between differentiation and integration.
- master the derivation of higher-dimensional functions.

**Contents**

1. Sequences and series
   - 1.1 Sequences and series
   - 1.2 Convergence of infinite series
   - 1.3 power series
2. Functions and reverse functions
   - 2.1 Continuous functions
   - 2.2 Exponential and logarithm function
   - 2.3 Trigonometric functions and their inverse functions
3. Differential calculus
   - 3.1 Derivatives and higher derivatives
   - 3.2 curve discussion
   - 3.3 Rules (chain rule, product rule, quotient rule ...)
   - 3.4 Taylor Rows

4. Integral calculus
   - 4.1 The Riemann Integral
   - 4.2 Specific and indefinite integrals
   - 4.3 The fundamental theorem of differential and integral calculus
   - 4.4 Volumes and shells of rotary bodies
   - 4.5 Paths and lengths

5. Differential calculus in the Rn
   - 5.1 Partial Derivation
   - 5.2 Total Derivation
   - 5.3 Gradients of vector-valued functions and matrices

**Literature**

**Compulsory Reading**

**Further Reading**


- Deisenroth, M.P., Faisal, A.A., & Ong, C.S. (2020). Mathematics for Machine Learning. Cambridge University Press.
- Magnus, R. (2020). Fundamental Mathematical Analysis. Springer International Publishing.

### Study Format Distance Learning

| **Study Format** | **Course Type** |
|---|---|
| Distance Learning | Online Lecture |

| **Information about the examination** | |
|---|---|
| **Examination Admission Requirements** | **BOLK:** yes<br>**Course Evaluation:** no |
| **Type of Exam** | Exam, 90 Minutes |

| **Student Workload** | | | | | |
|---|---|---|---|---|---|
| **Self Study** | **Presence** | **Tutorial** | **Self Test** | **Practical Experience** | **Hours Total** |
| 90 h | 0 h | 30 h | 30 h | 0 h | 150 h |

| **Instructional Methods** | |
|---|---|
| ☐ Learning Sprints® | ☑ Review Book |
| ☑ Course Book | ☐ Creative Lab |
| ☐ Vodcast | ☐ Guideline |
| ☑ Shortcast | ☑ Live Tutorium/Course Feed |
| ☑ Audio | |
| ☑ Exam Template | |

DLBDSMFC01

# Mathematics: Linear Algebra

**Module Code: DLBDSMFLA**

| Module Type | Admission Requirements | Study Level | CP | Student Workload |
|---|---|---|---|---|
| see curriculum | none | BA | n/a | 150 h |

| Semester / Term | Duration | Regularly offered in | Language of Instruction |
|---|---|---|---|
| see curriculum | Minimum 1 semester | WiSe/SoSe | English |

**Module Coordinator**

Prof. Dr. Moustafa Nawito (Mathematics: Linear Algebra)

**Contributing Courses to Module**

- Mathematics: Linear Algebra (DLBDSMFLA01)

**Module Exam Type**

| Module Exam | Split Exam |
|---|---|
| Study Format: Distance Learning<br>Exam, 90 Minutes | |

**Weight of Module**

see curriculum

**Module Contents**

- Matrix algebra
- Vector spaces
- Linear and affine transformations
- Analytical geometry
- Matrix decomposition

**Learning Outcomes**

**Mathematics: Linear Algebra**

On successful completion, students will be able to

- explain fundamental notions in the domain of linear equation systems.
- exemplify properties of vectors and vector spaces.
- summarize characteristics of linear and affine mappings.
- identify important relations in analytical geometry.
- utilize different methods for matrix decomposition.

| **Links to other Modules within the Study Program** | **Links to other Study Programs of IU International University of Applied Sciences** |
|---|---|
| This module is similar to other modules in the field of Methods | All Bachelor Programmes in the IT & Technology fields |

# Mathematics: Linear Algebra

**Course Code: DLBDSMFLA01**

| Study Level | Language of Instruction | Contact Hours | CP | Admission Requirements |
|---|---|---|---|---|
| BA | English | | n/a | none |

**Course Description**

Linear algebra is a fundamental subject in mathematics. Its historical origin lies in the development of solution techniques for systems of linear equations arising from geometric problems. Numerous scientific and engineering applications can be solved using its methods. This course introduces the foundations of linear algebra and its basic notions like vectors and matrices. It then builds upon this foundation by introducing the derivation of solution techniques for problems in analytical geometry.

**Course Outcomes**

On successful completion, students will be able to

- explain fundamental notions in the domain of linear equation systems.
- exemplify properties of vectors and vector spaces.
- summarize characteristics of linear and affine mappings.
- identify important relations in analytical geometry.
- utilize different methods for matrix decomposition.

**Contents**

1. Fundamentals
   - 1.1 Systems of linear equations
   - 1.2 Matrices as compact representations of linear equations
   - 1.3 Matrix algebra
   - 1.4 Inverse and trace
2. Vector Spaces
   - 2.1 Definition
   - 2.2 Linear combination and linear dependance
   - 2.3 Base, span, and rank
3. Linear and affine mappings
   - 3.1 Matrix representations of linear mappings
   - 3.2 Image and kernel
   - 3.3 Affine spaces and sub-spaces
   - 3.4 Affine mappings

4. Analytical Geometry
   - 4.1 Norms
   - 4.2 Inner and dot product
   - 4.3 Orthogonal projections
   - 4.4 Rotations

5. Matrix Decomposition
   - 5.1 Determinant and trace
   - 5.2 Eigenvalues and eigenvectors
   - 5.3 Cholesky decomposition
   - 5.4 Eigenvalue decomposition and diagonalisation
   - 5.5 Singular value decomposition

**Literature**

**Compulsory Reading**

**Further Reading**


- Mathai, A. M., & Haubold, H. J. (2017). Linear algebra, a course for physicists and engineers (1st ed.) De Gruyter.
- Neri, F. (2019). Linear algebra for computational sciences and engineering (2nd ed.) Springer.
- Shilov, G. E. (1977). Linear algebra. Dover Publications.
- Strang, G. (2020). Introduction to linear algebra. (5th ed.) Cambridge Press.

### Study Format Distance Learning

| Study Format | Course Type |
|---|---|
| Distance Learning | Online Lecture |

| Information about the examination | |
|---|---|
| **Examination Admission Requirements** | **BOLK:** yes<br>**Course Evaluation:** no |
| **Type of Exam** | Exam, 90 Minutes |

| Student Workload | | | | | |
|---|---|---|---|---|---|
| **Self Study** | **Presence** | **Tutorial** | **Self Test** | **Practical Experience** | **Hours Total** |
| 90 h | 0 h | 30 h | 30 h | 0 h | 150 h |

| Instructional Methods | |
|---|---|
| ☐ Learning Sprints® | ☑ Review Book |
| ☑ Course Book | ☐ Creative Lab |
| ☐ Vodcast | ☐ Guideline |
| ☑ Shortcast | ☑ Live Tutorium/Course Feed |
| ☑ Audio | |
| ☑ Exam Template | |

DLBDSMFLA01

# Statistics: Probability and Descriptive Statistics

**Module Code: DLBDSSPDS**

| Module Type | Admission Requirements | Study Level | CP | Student Workload |
|---|---|---|---|---|
| see curriculum | none | BA | n/a | 150 h |

| Semester / Term | Duration | Regularly offered in | Language of Instruction |
|---|---|---|---|
| see curriculum | Minimum 1 semester | WiSe/SoSe | English |

**Module Coordinator**

Dr. Stefan Stöckl (Statistics: Probability and Descriptive Statistics )

**Contributing Courses to Module**

- Statistics: Probability and Descriptive Statistics (DLBDSSPDS01)

**Module Exam Type**

| Module Exam | Split Exam |
|---|---|
| Study Format: Distance Learning<br>Exam, 90 Minutes<br>Study Format: myStudies<br>Exam, 90 Minutes | |

**Weight of Module**

see curriculum

**Module Contents**

- Probability
- Random variables
- Joint distributions
- Expectation and variance
- Inequalities and limit theorems

**Learning Outcomes**

**Statistics: Probability and Descriptive Statistics**

On successful completion, students will be able to

- define probability, random variable, and probability distribution.
- understand the concept of Bayesian statistics.
- grasp the definition of joint and marginal distributions.
- calculate expectation values and higher moments.
- comprehend important inequality equations and limit theorems.

| Links to other Modules within the Study Program | Links to other Study Programs of IU International University of Applied Sciences |
|---|---|
| This module is similar to other modules in the field of Methods | All Bachelor Programmes in the Business & Management fields |

# Statistics: Probability and Descriptive Statistics

**Course Code: DLBDSSPDS01**

| Study Level | Language of Instruction | Contact Hours | CP | Admission Requirements |
|---|---|---|---|---|
| BA | English | | n/a | none |

**Course Description**

Statistical description and analysis are the foundations for data-driven analysis and prediction methods. This course introduces the fundamentals, beginning with a formal definition of probabilities and introduction to the concepts underlying Bayesian statistics.Random variables and probability density distributions are then discussed, as well as the concept of joint and marginal distributions. The importance of various discrete and continuous distributions and their applications is stressed.Characterizing distributions is an important aspect of describing the behavior of probability distributions. Students are familiarized with expectation values, variance, and covariance. The concepts of algebraic and central moments and moment-generating functions complement the characterization of probability distributions.Finally, this course focuses on important inequalities and limit theorems such as the law of large numbers or the central limit theorem.

**Course Outcomes**

On successful completion, students will be able to

- define probability, random variable, and probability distribution.
- understand the concept of Bayesian statistics.
- grasp the definition of joint and marginal distributions.
- calculate expectation values and higher moments.
- comprehend important inequality equations and limit theorems.

**Contents**

1. Probability
   - 1.1 Definitions
   - 1.2 Independent events
   - 1.3 Conditional probability
   - 1.4 Bayesian statistics
2. Random Variables
   - 2.1 Random Variables
   - 2.2 Distribution functions and probability mass functions
   - 2.3 Important discrete probability distributions
   - 2.4 Important continous probability distributions

3. Joint Distributions
   - 3.1 Joint distributions
   - 3.2 Marginal distributions
   - 3.3 Independent random variables
   - 3.4 Conditional distributions

4. Expectation and Variance
   - 4.1 Expectation of a random variable, conditional expectations
   - 4.2 Variance and covariance
   - 4.3 Expectations and variances of important probability distributions
   - 4.4 Algebraic and central moments
   - 4.5 Moment-generating functions

5. Inequalities and Limit Theorems
   - 5.1 Probability inequalities
   - 5.2 Inequalities for expectations
   - 5.3 The law of large numbers
   - 5.4 Central limit theorem

**Literature**

**Compulsory Reading**

**Further Reading**


- Downey, A.B. (2011). Think stats (2nd ed.). Sebastopol, CA: O'Reilly
- Kim, A. (2019). Exponential Distribution—Intuition, Derivation, and Applications. Available online.
- Wasserman, L. (2004). All of Statistics: A concise course in statistical inference. New York, NY: Springer

### Study Format Distance Learning

| **Study Format** | **Course Type** |
|---|---|
| Distance Learning | Online Lecture |

| **Information about the examination** | |
|---|---|
| **Examination Admission Requirements** | **BOLK:** yes<br>**Course Evaluation:** no |
| **Type of Exam** | Exam, 90 Minutes |

| **Student Workload** | | | | | |
|---|---|---|---|---|---|
| **Self Study** | **Presence** | **Tutorial** | **Self Test** | **Practical Experience** | **Hours Total** |
| 90 h | 0 h | 30 h | 30 h | 0 h | 150 h |

| **Instructional Methods** | |
|---|---|
| ☐ Learning Sprints® | ☑ Review Book |
| ☑ Course Book | ☐ Creative Lab |
| ☐ Vodcast | ☐ Guideline |
| ☑ Shortcast | ☐ Live Tutorium/Course Feed |
| ☑ Audio | |
| ☑ Exam Template | |

### Study Format myStudies

| Study Format | Course Type |
|---|---|
| myStudies | Lecture |

| Information about the examination | |
|---|---|
| **Examination Admission Requirements** | **BOLK:** yes<br>**Course Evaluation:** no |
| **Type of Exam** | Exam, 90 Minutes |

| Student Workload | | | | | |
|---|---|---|---|---|---|
| **Self Study** | **Presence** | **Tutorial** | **Self Test** | **Practical Experience** | **Hours Total** |
| 90 h | 0 h | 30 h | 30 h | 0 h | 150 h |

**Instructional Methods**

- ☐ Learning Sprints®
- ☑ Course Book
- ☐ Vodcast
- ☑ Shortcast
- ☑ Audio
- ☑ Exam Template
- ☑ Review Book
- ☐ Creative Lab
- ☐ Guideline
- ☐ Live Tutorium/Course Feed

# Statistics - Inferential Statistics

**Module Code: DLBDSSIS**

| Module Type | Admission Requirements | Study Level | CP | Student Workload |
|---|---|---|---|---|
| see curriculum | DLBDSSPDS01 | BA | n/a | 150 h |

| Semester / Term | Duration | Regularly offered in | Language of Instruction |
|---|---|---|---|
| see curriculum | Minimum 1 semester | WiSe/SoSe | English |

**Module Coordinator**

Dr. Stefan Stöckl (Statistics - Inferential Statistics)

**Contributing Courses to Module**

- Statistics - Inferential Statistics (DLBDSSIS01)

**Module Exam Type**

| Module Exam | Split Exam |
|---|---|
| Study Format: Distance Learning<br>Exam, 90 Minutes | |

**Weight of Module**

see curriculum

**Module Contents**

- Point estimation
- Uncertainties
- Bayesian inference & non-parametric techniques
- Statistical testing
- Statistical decision theory

**Learning Outcomes**

**Statistics - Inferential Statistics**

On successful completion, students will be able to

- understand point estimation methods.
- apply maximum likelihood and ordinary least squares method to estimate parameters.
- comprehend the concept of statistical and systematic errors.
- employ error propagation methods.
- utilize Bayesian inference and non-parametric techniques.
- evaluate statistical tests.
- grasp the fundamentals of statistical decision theory.

| Links to other Modules within the Study Program | Links to other Study Programs of IU International University of Applied Sciences |
|---|---|
| This module is similar to other modules in the field of Methods | All Bachelor Programmes in the IT & Technology fields |

# Statistics - Inferential Statistics

**Course Code: DLBDSSIS01**

| Study Level | Language of Instruction | Contact Hours | CP | Admission Requirements |
|---|---|---|---|---|
| BA | English | | n/a | DLBDSSPDS01 |

**Course Description**

Statistical analysis and understanding are the foundations of data-driven methods and machine learning approaches.This course gives a thorough introduction to point estimators and discusses various techniques to estimate and optimize parameters. Special focus is given to a detailed discussion of both statistical and systematic uncertainties as well as propagation of uncertainties.Bayesian statistics is fundamental to data-driven approaches, and this course takes a close look at Bayesian techniques such as Bayesian parameter estimation and prior probability functions.Furthermore, this course gives an in-depth overview of statistical testing and decision theory, focusing on aspects such as A/B testing, hypothesis testing, p-values, and multiple testing which are fundamental to statistical analysis approaches in a broad range of practical applications.

**Course Outcomes**

On successful completion, students will be able to

- understand point estimation methods.
- apply maximum likelihood and ordinary least squares method to estimate parameters.
- comprehend the concept of statistical and systematic errors.
- employ error propagation methods.
- utilize Bayesian inference and non-parametric techniques.
- evaluate statistical tests.
- grasp the fundamentals of statistical decision theory.

**Contents**

1. Point Estimation
   - 1.1 Method of moments
   - 1.2 Sufficient statistics
   - 1.3 Maximum likelihood
   - 1.4 Ordinary least squares
   - 1.5 Resampling techniques
2. Uncertainties
   - 2.1 Statistical and systematic uncertainties
   - 2.2 Propagation of uncertainties

3. Bayesian Inference & Non-parametric Techniques
   - 3.1 Bayesian parameter estimation
   - 3.2 Prior probability functions
   - 3.3 Parzen windows
   - 3.4 K-nearest-neighbours

4. Statistical Testing
   - 4.1 A/B testing
   - 4.2 Hypothesis tests & test statistics
   - 4.3 P-values & confidence intervals
   - 4.4 Multiple testing

5. Statistical Decision Theory
   - 5.1 The risk function
   - 5.2 Maximum likelihood, Minimax, and Bayes
   - 5.3 Admissibility and Stein's paradox

**Literature**

**Compulsory Reading**

**Further Reading**


- Wasserman, L. (2004). All of statistics: A concise course in statistical inference. Springer.
- Downey, A. B. (2014). Think stats (2nd ed.). O'Reilly.
- Downey, A.B. (2013). Think bayes. O'Reilly.

### Study Format Distance Learning

| **Study Format** | **Course Type** |
|---|---|
| Distance Learning | Online Lecture |

| **Information about the examination** | |
|---|---|
| **Examination Admission Requirements** | **BOLK:** yes<br>**Course Evaluation:** no |
| **Type of Exam** | Exam, 90 Minutes |

| **Student Workload** | | | | | |
|---|---|---|---|---|---|
| **Self Study** | **Presence** | **Tutorial** | **Self Test** | **Practical Experience** | **Hours Total** |
| 90 h | 0 h | 30 h | 30 h | 0 h | 150 h |

| **Instructional Methods** | |
|---|---|
| ☐ Learning Sprints® | ☑ Review Book |
| ☑ Course Book | ☐ Creative Lab |
| ☐ Vodcast | ☐ Guideline |
| ☑ Shortcast | ☐ Live Tutorium/Course Feed |
| ☑ Audio | |
| ☑ Exam Template | |