

# DS Brush-up Courses - Introduction to Mathematics

Lecturer: **Piotr Zwiernik**

## Overview and Objectives

The mathematics brush up course aims to bring students from diverse backgrounds to a common platform with relation to the required mathematical knowledge and tools for the masters' program. It is an intensive course that covers linear algebra, intermediate probability and intermediate statistics.

## Course Outline

### 1. Linear algebra

- vectors, linear spaces, linear independence, bases, dimension
- linear transformations, matrices (transposition, inverses, determinants)
- inner products, orthogonality, projection theorem
- norms
- eigenvalues, eigenvectors, matrix diagonalization
- quadratic forms, positive definite matrices
- SVD, Cholesky decomposition
- basic multivariate calculus: differentiation of linear and quadratic forms

### 2. Probability

- random events, probability, independent events
- random variables, distribution functions, density functions
- binomial, geometric, Poisson, uniform, exponential, normal distributions;
- joint distributions (discrete and continuous); independence; covariance matrix,
- conditional probability, conditional expectation; Bayes theorem;
- multivariate normal distribution
- expectation and variance of sums of random variables
- Chebyshev's inequality; law of large numbers; and central limit theorem.

### 3. Introduction to intermediate statistics

- parametric *iid* models, basic linear regression
- estimating parametric models by maximum likelihood
- basic likelihood theory for multi-parameter models: MLE, asymptotic theory (Fisher information, asymptotic normality, confidence intervals)
- introduction to likelihood ratio tests

## DS Brush-up Courses - Introduction to Mathematics

### Evaluation

Evaluations are based on a final test given at the end of the course. The exam is definition based and ensures that students demonstrate appropriate levels of understanding of the presented concepts. Clearing the exam is compulsory. Students will get two attempts to pass it.

### Materials

The resources listed here are not strictly used to deliver the brush up. A list of recommended resources provided below serves as an excellent starting point.

#### Linear Algebra

- G. Strang, *An Introduction to Linear Algebra*
- C. Bishop, *Pattern Recognition and Machine Learning*, see the appendix.

#### Probability

- L. Wasserman, *All of statistics*
- Bishop

#### Statistics

- Wasserman
- Bishop