

PH.D. COURSE SCHEDULE, SPRING 2022
Department of Statistics, Uppsala University

Course Advanced Multivariate Statistics (15 ECTS)

Teacher Rauf Ahmad: *rauf.ahmad@statistik.uu.se*

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Recommended books The course will mainly follow Mardia, KV, JT Kent, JM Bibby (1979; Reprint 2003). *Multivariate analysis*, Academic Press, London. Occasionally, some extensions will be discussed for which the following books are useful:

Hastie, T, R Tibshirani, J Friedman (2017, corrected 2nd ed.). *Elements of statistical learning.*, Springer.

Hastie, T, R Tibshirani, M Wainright (2016). *Statistical learning with sparsity: The LASSO and generalizations*, CRC.

Anderson, TW (2003). *An introduction to multivariate statistical analysis*. Wiley.

Structure Lectures and exercises; Lectures will be on Zoom (links will be provided later).

Assessment Assessment and gradation will be in two parts. Each part should be passed separately with at least 50% points to pass the course.

Part I Two sets of exercises will be handed-in, the solutions of which should be submitted by the specified deadlines; For details, see the exercises table below!

Part II Individual oral exam, aimed at evaluating the student for comprehension of deeper concepts on the topics discussed in the lectures; Questions can be asked from the submitted exercises as well as generally from the material covered during the course; The tentative date for oral exam is April 26, 2022 (subject to change!)

NOTE: A student failing in one part will get one additional chance to repeat that part; A student failing in both parts simultaneously, or failing in the same part twice will fail the course!

Pre-requisites Basic multivariate statistics (at the level of, e.g., Johnson & Wichern); Additionally, Linear algebra; Statistical inference and Univariate linear model theory

Course plan Following chapters from Mardia et al. will be covered (with intermittent additions from other books):

Tatjana Pavlenko: Chapters 1-6

Rauf Ahmad: Chapters 8, 10-13

All lectures are 3-hour duration, including one or two short breaks.

Chapter-wise detailed contents are as following (to be extended as and when needed):

Chap 1: Introduction; Multivariate problems and techniques.

Chap 2: Basic properties of random vectors; Population moments and Mahalanobis space; Characteristic functions; Some multivariate generalizations of univariate distributions; Families of distributions; Limit theorems.

Chap 3: Multivariate normal distribution theory; Characterization and properties; Random matrices and the Wishart distribution; statistics based on the Wishart distribution; Hotelling's T^2 distribution; Mahalanobis distance; Other statistics related to the multivariate normal distribution.

Chap 4: Theory of point estimation; Likelihood and sufficiency; Bayesian inference.

Chap 5: Hypothesis testing; One- and multi-sample hypotheses; Simultaneous confidence intervals.

Chap 6: Multivariate regression analysis; Maximum likelihood and Least squares estimation; Linear methods for regression; High-dimensional regression modeling; Sparse multivariate methods (Lasso-based and other regularization techniques for linear models).

Chap 8: Introduction, PC transformation and properties; PC spaces and optimality; Sample PCA; Statistical inference; No. of PCs; PC regression; Extensions and recent developments.

Chap 10: Introduction, mathematical development and properties; Tests of independence and zero correlation; Inference; Other measures and extensions.

Chap 11: Introduction; Problem of misclassification; Two-class classifiers; Fisher's idea of classification; Multi-class case; Logistic classifier; Inference; Value of classification; Extensions and recent additions.

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SCHEDULE: ADVANCED MULTIVARIATE STATISTICS, SPRING 2022

Date	Time	Room	Contents
Thursday, February 17	13:15-16:00	B115	Lecture 1: Chapters 1-2
Thursday, February 24	13:15-16:00	B115	Lecture 2: Chapters 3-4
Thursday, March 02	13:15-16:00	B115	Lecture 3: Chapters 5
Thursday, March 10	13:15-16:00	B115	Lecture 4: Chapters 6
Tuesday, March 15	14:15-17:00	B115	Lecture 5: Chapter 8
Monday, March 21	09:15-12:00	B115	Lecture 6: Chapter 10
Wednesday, March 30	14:15-17:00	B115	Lecture 7: Chapter 11
Monday, April 04	09:15-12:00	B115	Lecture 8: Chapters 11-13

EXERCISES: ADVANCED MULTIVARIATE STATISTICS, SPRING 2022

Chapters	Hand-in Exercises
<u>SET I</u>	<u>DEADLINE: MARCH 25, 2022</u>
1-2	4.1, 5.2, 5.1, 5.3 1.1, 2.2, 6.6
3-4	2.6, 3.4, 3.5, 4.5, 4.6, 4.7, 4.9, 4.10, 4.12, 5.1, 6.1, 7.1, 7.4 1.1, 2.1, 2.2, 2.3, 2.6, 2.9
5	2.4, 3.2, 3.3(a,b), 3.5a, 5.1, 5.2
6	2.1, 2.3, 2.4, 3.1, 3.2, 6.1, 6.2
<u>SET II</u>	<u>DEADLINE: APRIL 19, 2022</u> Exercises for Part II will be added in due course!