Stockholm University

Spring 2025

Course Description
Multivariate Analysis, ST744A
Advanced level, 7.5 ECTS credits

COURSE CONTENT

The course consists of two course modules:
1. Multivariate analysis (6 ECTS credits)
2. Compulsory exercise in multivariate analysis (1.5 ECTS credits)

The course provides deeper knowledge of the statistical theory that underlies multivariate statistical methods. The link between multivariate and corresponding univariate techniques will be demonstrated. The course covers the theoretical, computational, and interpretive issues of multivariate analysis.

In Module 1, the central theme is the multivariate linear model and the multivariate normal distribution (MND). The properties of the MND and inference about its parameters are considered. Statistical methods studied in the course are the multivariate analysis of variance, profile analysis, multivariate regression and canonical correlation analysis. A special attention is given to the assumptions for different statistical methods and their validation.
Module 2 includes practical multivariate data analysis using statistical software R. Computer literacy and matrix algebra are essential for this course. Matrix algebra is used through the course as a necessary tool for the inference as well as computer sessions. An overview about necessary concepts from matrix algebra useful for the course will be given.

LEARNING OUTCOMES

To pass the course the student should be able to:
- account for important theorems and concepts in multivariate analysis,
- account for the most common multivariate methods,
- apply the multivariate methods in the framework of the multivariate analysis,
- use the statistical software to analyse data.

Course literature

Johnson, R.A., Wichern, D.W.(2007). *Applied Multivariate Statistical Analysis.* 6th ed. Pearson Education.

Reference literature: Complementary material relevant for this course will be provided via Athena.

TEACHERS

Course coordinator/lecturer: Tatjana von Rosen, tatjana.vonrosen@stat.su.se.

Teaching assistant: Yijie Niu, Yijie.Niu@stat.su.se.

COMMUNICATION & COURSE HOMEPAGE

Most of the students' engagement in the course will happen through the Stockholm university's learning platform **Athena**. All the necessary information concerning the administration of the course, examination, computer labs, compulsory exercise will be published on the course website in Athena. You can also interact with the teachers and other students in Athena via discussion boards (forum), chats and message system.

TEACHING

The course comprises 9 lectures (L1-L9), 6 computer sessions (CL1-CL6), and work on compulsory home assignments (HW1-HW5). One lecture is reserved for a compulsory seminar (F8). During this lecture-seminar the course participants will orally present their compulsory home assignmets (more detailed instructions will be provided in the coming weeks via Athena). During the lectures, different topics on multivariate analysis will be introduced and relevant numerical examples will be considered. During computer labs students will gain practical skills on conducting a multivariate analysis using statistical software R. Detailed instructions will be given in the connection with the lecture/computer lab.

PRELIMINARY TEACHING PLAN

With reservation for changes, the following is a tentative list of the topics to be covered in the lectures scheduled for **Spring 2024**. The schedule of the course is available through Web.

	Content	**Reading**
L1	Introduction and overview of the course. Aspects of multivariate statistical modelling. Essential matrix algebra.	Chapter 1, 3
L2	Random vectors. Multivariate Normal Distribution.	Chapter 2
CL1	Data processing, essential graphics, matrix algebra useful for statistics.	
L3	Inference about a mean vector.	Chapter 5
HW1	Work on compulsory HA1	
CL2	Multivariate Normal Distribution, inference about a mean vector.	
L4	One-Way Multivariate Analysis of Variance.	Chapter 6
CL3	One-way MANOVA	
HW2	Work on compulsory HA2	
L5	Two-Way Multivariate Analysis of Variance.	Chapter 6
CL4	Two-Way MANOVA	
HW3	Work on compulsory HA3	
L6	Profile Analysis.	Chapter 6
CL5	Profile Analysis.	
HW4	Work on compulsory HA4.	
L7	Multivariate Regression. Canonical Correlation Analysis.	Chapter 7, 10
CL6	Multivariate Regression. Canonical Correlation Analysis.	
HW5	Work on compulsory HA5.	
L8	Seminar. Oral presentation of students' compulsory Home Assignments.	
L9	Repetition. Summary of the course.	

COMPULSORY ATTENDANCE

Attendance at lectures and computer labs is not obligatory. However, it is mandatory to attend **Lecture 8**. This lecture is reserved for the oral presentations of students' compulsory exercises. Students who fail to meet this requirement are considered to fail the Module 2 unless they have previously given notice to the course examiner (in this case they have to make an oral presentation on some other date specified by the examiner).

COMPULSORY HOME ASSIGNMENTS

Five compulsory Home Assignments (HA) should be conducted during the course. These HAs correspond to the statistical methods considered in the course. Student's work will be assessed regarding both technical skills and ability to communicate the findings. Due dates will be posted for each assignment on the Athena course site. All home assignments are expected to be submitted in electronic form. The assignments should be uploaded in Moodle course website. Email submissions to the instructor will not be accepted.

EXAMINATION

a. The learning outcomes of the course will be assessed through a written and oral examination.
b. Grading is done according to a seven-point scale related to the specified learning outcomes:
A = Excellent; B = Very Good; C = Good; D = Satisfactory; E = Adequate; Fx = Inadequate; F = Totally Inadequate.
c. The assessment criteria for the course will be distributed at the beginning of the course.
d. In order to pass the course, the grade **E** or higher is required on Module 1 and **Pass** on course Module 2.
e. Students who have received the grade *Fx* or *F* on the written test are entitled to at least four additional examinations to achieve the lowest grade *E* as long as the course is given.
If a student has received the grade *Fx* on Module 2 but is close to passing the assignment, there may be a possibility to hand in an additional assignment. The assignment should be handed in within the given time frame and after the examiner having advised on the need to revise the assignment.
Students who have received the grade *E* on the written test may not retake this examination in order to attempt to achieve a higher grade.
Students who have received the grade *Fx* or *F* on the written/oral test on two occasions by the same examiner have the right to request that a different examiner be appointed to set the grade of the examination. The request must be in writing and sent to the head of the department. The examination denotes all compulsory elements of the course.
Every time the course is given, there should be two examination opportunities during the current semester.

Module 1, **Multivariate Analysis** (6 ECTS credits) is examined through a written individual test. Pocket calculator without stored formulas and text are allowed. Formula sheet and statistical tables will be provided with the test. When obtaining grades **F** or **Fx** in the written test, no extra exercises or extra assignments will be given to obtain a passing grade.

Module 2, **Compulsory Home Assignments in Multivariate Analysis** (1.5 ECTS credits), is examined through five hand-in assignments which comprise a written report (compulsory) and the oral presentation (compulsory) of the obtained results. Home Assignments should be completed individually or in group (this will be specified in Athena). The Compulsory Home Assignments (Module 2) is graded as: Pass, i.e. all five Home Assignments are done correctly and the oral presentation is appropriately done, or Fail, i.e. at leat one of five hand-in assignments is not done correctly or/and the oral presentation is done inappropriately). If a compulsory Home Assignment or/and Oral presentation is graded as Fail, the student will have a chance to re-submit the hand-in assignment(s) or/and make a new oral presentation. This has to be done within a time period specified by the course coordinator/examiner.

Interim

When the course syllabus has been withdrawn, the student has the right to request examination once per semester during a period of three semesters in accordance with this syllabus. The request must be in writing and sent to the head of department.

Limitations

This course may not be included in a degree together with the course Multivariate Methods (ST731A) 7.5 ECTS credits, or equivalent.

Note that it is required to sign up for the examination, as well as for the re-examination, at least one week in advance.

CRITERIA FOR ASSESSMENT

Examination in Module 1 is conducted through the written test. The writing time is 5 hours. Pocket calculator without stored formulas and text are allowed. Formula sheet and statistical tables will be provided with the test.

The following seven criteria-referenced grades are used in Module 1, Multivariate Analysis, 6 ECTS credits:

A: Excellent; B: Very good; C: Good; D: Satisfactory; E: Adequate; Fx: Inadequate; F: Totally Inadequate.

A (Excellent): The student can in a well-structured way present and correctly use the theory of the multivariate statistics which has been considered in the course. Moreover, the student can apply this theory to practical problems in multivariate analysis that not necessarily have been discussed in the course. The student can present correctly all problem solutions and use a correct statistical language. Corresponds to 90-100% of the total written test score.

B (Very good): The student can in a well-structured way describe and correctly use the theory of the multivariate statistics which has been considered in the course. The student can apply this theory to practical problems in multivariate analysis that have been partly discussed in the course. The student can clearly present all correct problem solutions and use a correct statistical language. Corresponds to 80-89% of the total written test score.

C (Good): The student can in a well-structured way describe and correctly use the theory of the multivariate statistics which has been considered in the course. Moreover, the student can apply this theory to majority of practical problems in multivariate analysis that have been discussed in the course. The student can present correct solutions for the most problems and use a correct statistical language. Corresponds to 70-79% of the total written test score.

D (Satisfactory): The student can correctly describe and in a satisfactory way use the theory of the multivariate statistics which has been considered in the course. The student can apply this theory to the majority of practical problems in multivariate analysis that have been directly addressed in the course. The student can present in the majority of cases correct problem solutions and use a satisfactory statistical language. Corresponds to 60-69% of the total written test score.

E (Adequate): The student can in a largely correct way describe and use the theory of the multivariate statistics which has been considered in the course. The student can in a largely correct way apply this theory to the majority of practical problems in multivariate analysis that have been directly addressed in the course. The student can present satisfactory problem solutions and use a satisfactory statistical language. Corresponds to 50-59% of the total written test score.

Fx (Inadequate): The student can not correctly describe and use the theory of the multivariate statistics which has been considered in the course. The student fails to present satisfactory problem solutions and use a satisfactory statistical language. Corresponds to 40-49% of the total written test score.

F (Totally Inadequate): The student can not describe and adequately use the theory of the multivariate statistics which has been considered in the course. The student can not satisfactory solve problems in multivariate analysis which are directly based on the course material and fails to correctly use a statistical language. Corresponds to 0-39% of the total written test score.

The following two criteria-referenced grades are used in Module 2, Compulsory Exercise in Multivariate Analysis, 1.5 ECTS credits:

Pass: The student can apply appropriate multivariate methods to correctly complete the compulsory exercise. The student should be able in a satisfactory way to present both in a written form and orally his/her findings, and interpret them using proper graphics, descriptive statistics, significance test etc., explain important concepts of multivariate statistics relevant to the compulsory exercise. The student can correctly use statistical software SAS and R and summarize his/her work in a well-written report using a correct statistical language.

Fail: The student cannot identify and apply appropriate multivariate methods to correctly complete the compulsory exercise or/and the student is not able in a satisfactory way to present neither in a written form nor orally his/her findings, interpret them using proper graphics, descriptive statistics, significance test etc. or/and the student cannot explain important concepts of multivariate statistics relevant to the compulsory exercise or/and the student cannot correctly use statistical software SAS/R or/and the student cannot summarize his/her work in a well-written report using a correct statistical language.

ARTIFICIAL INTELLIGENCE, AI-TOOLS AND PLAGIARISM

- Use of AI-tools is allowed for purposes of knowledge acquisition and practice but not to produce material for any form of the examination.
- All forms of plagiarism are prohibited and these include even texts generated by AI-tools.
- Use of AI-tools is allowed for purposes for improving a self-written original text is not allowed
- Software for text-matching and detectors for AI-generated text are used by the department.

You can read more about Stockholm Universitys guidelines for disciplinary matters (the English version can be added if/when the need arises).