BASIC MATHEMATICS: CALCULUS

Tuesday 9:00–10:45 and Thursday 13:45–15:30

CONTENT

This introductory course focuses on basic concepts of calculus starting with functions of a single variable. First you explore simple linear and nonlinear differential equations. Such equations are key in explaining the dynamic behavior of many different systems in a wide variety of fields. This serves as a motivation to learn about techniques, such as differentiation, integration, expansion in a small variable, and complex numbers.

Next you learn to use powerful tools to study systems of many variables: linear vector spaces, linear operators (matrices) in such spaces, and key properties of matrices. You also extend techniques such as differentiation to functions of several variables and learn about their geometrical representation. The course concludes with various approaches to optimization of functions of several variables.

The techniques you learn in this course have proven to be highly effective in a wealth of areas as will be illustrated by examples in various fields. Some attention is paid to underlying mathematical foundations, but the focus is on understanding the methods and on learning to apply the techniques.

AIMS

After completing this course students are able to:

- apply basic techniques of single-variable calculus, such as differentiation, integration and Taylor expansions,
- find solutions to simple ordinary differential equations,
- apply basic techniques of linear algebra, including matrix diagonalization,
- optimize functions of several variables, with and without constraint,
- understand and extend these techniques beyond the level of recipes so they can be applied to new problems in their future field of study,
- make basic use of the symbolic manipulation program *Mathematica* for the purpose of evaluating expressions and creating graphs.

COURSE PROCEEDINGS

In general, Tuesday classes will be lectures during which the main techniques and ideas are introduced, some typical examples are shown and the underlying theory is discussed. Please read the corresponding lecture section in the course notes before the lecture in question, and bring these notes to class. In this way we can make the most efficient use of class time. The main goal of the lectures is to stimulate thought and foster understanding, not to provide exhaustive coverage of basic facts that you can easily read on your own.

Thursday classes consist of guided practical work. You should prepare for those sessions by doing as many as possible of the required exercises, so that you can use the class time to ask questions about the ones you had trouble with. Exercises you did not finish during class hours, you should finish afterwards.

ASSESSMENT

Your final grade is based on the following components:

- Midterm exam (20%)
- Final exam (30%)
- Take-home assignments (30%)
- In-class presentations (10%)
- Class participation (10%)

The midterm exam will take place on the last class before the midterm break (Thursday October 15), and the final exam at the last class of the semester (Thursday December 17).

The exercises assigned from the textbook show the types of problems that will be on the exams (these exercises themselves are not graded). At the exams you may bring the formula sheet at the end of the course notes but no calculator. Exams, take-home assignments and presentations will be graded on a scale of 100 and then converted to letter grades according to the attached table.

TAKE-HOME ASSIGNMENT REGULATIONS

Seven take-home problems will be assigned. This will provide opportunities for more in-depth problems than time allows for on exams and weekly exercises. See the attached sheet for details.

PRESENTATION REGULATIONS

Each student will give two presentations at some point in the semester. Presentation problems will be assigned from the course notes (interested students can also propose problems of their own). It is important that everyone brings the printed notes so that they can have the problem in front of them and follow the reasoning of the presenter. As a rule of thumb the presentations should be about 15 minutes in length.

A+	96–100
A	88–96
A-	82–88
B+	77–82
B	73–77
B-	68–73
C+	64–68
C	60–64
C-	56–60
D+	53–56
D	50–53
D-	46–50
F	0–46

The presenter will write a complete solution of the problem, in the manner of the take-home assignments, which will account for 70 of the possible 100 points. This written version is to be handed in immediately following the presentation (unless errors requiring substantial rewriting were discovered during the presentation, in which case an extension is granted under penalty of point deduction).

The remaining 30 points are devoted to presentational aspects. Experience shows that presenters tend to focus too much on calculations and formulas, and not enough on the ideas involved, its visual and intuitive aspects, the way of thinking that leads to the solution, and why the problem is illuminating and interesting. These things, rather than calculations, should be the focus of your presentation. In particular your should not skip the "story" part of the problem insofar as it has one. Furthermore, the presenter should try to involve the class and prompt them to supply as many of the steps as possible. Ideally, the class rather than the presenter will supply most of the solution.

In the interest of time, very mundane calculations should be skipped. If the majority of the class can see at once the steps required to solve a particular equation, then you should simply remind them very briefly what the calculation consists in and then skip directly to the answer. The details should of course be in the written version.

TEXTBOOK

Mathematical Techniques, An introduction for the engineering, physical and mathematical sciences (fourth edition), by D.W. Jordan & P. Smith, Oxford University Press 2008; ISBN 978-0-19-928201-2.

PREREQUISITES

Secondary school knowledge of mathematics is required. This could be acquired in IB Higher Level Math, Dutch VWO "Wiskunde B" or "Wiskunde D", or similar "Calculus and Algebra" courses from a foreign high school; if in doubt, ask the lecturer as early as possible. Students who do not meet these requirements should take UCACCMAT01 first. As an indication, a well-prepared student will typically be comfortable with problems such as 3.4 and 4.2 in the textbook, and will probably be able to refresh his or her memory on problems such 17.3 and 17.10 without too much trouble (these latter topics are technically taught from scratch in this course but the pace is such that it helps to have seen them before).

TRACK INFORMATION

Students who intend to pursue a mathematics or physics track at UCU are strongly advised to take UCSCIMAT14 Foundations of Mathematics this semester, as it is offered only in the fall. Calculus is offered every semester.

TUTORING

Science student assistants are available for additional help outside of class. See the UCU intranet for their office hours, under Academic Departments Science.

CONTACT

Please do not hesitate to contact me with any questions.

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