UNIVERSITY OF BASILICATA STUDIES
DEPARTMENT OF MATHEMATICS, INFORMATICS AND ECONOMICS

COURSE: Linear Algebra

ACADEMIC YEAR: 2019/20

TYPE OF EDUCATIONAL ACTIVITY: Basic

TEACHER: Prof. Martin Funk

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Language: Italian

ECTS: 6 credits	n. of hours: 56 (32 lessons, 24 tutorials)	Campus: Potenza Dept: DiMIE Program: Computer Science Technologies	Semester: 1st

EDUCATIONAL GOALS AND EXPECTED LEARNING OUTCOMES

The course aims to supply an adequate basic knowledge in discrete mathematics and linear algebra: the main topic of the course is the study of various tools to attack and solve problems which can be formulated in terms of discrete mathematics or linear algebra.

The principal knowledge students should achieve is articulated as follows:

- elements of the theory of discrete structures and basic knowledge of linear algebra;
- elements of proof techniques used in the study of discrete structures;
- fundamentals of the theory of groups, rings and fields;
- basic knowledge of concepts of the theory of vector spaces;
- basic knowledge about the application of determinants;
- basic knowledge of strategies to solve systems of linear equations in several unknowns;
- fundamentals of the theory of (bases of) eigenvectors and the diagonalization of endomorphisms.

The principal abilities students should achieve are:

- to recognize discrete structures;
- to use calculus in rings and fields (in particular concerning finite fields);
- to calculate in terms of matrices and permutations;
- to determine determinants or ranks of matrices;
- to analyze and solve problems of analytical geometry;
- to analyze and solve systems of linear equations in several unknowns;
- to determine eigenvalues and eigenvectors of endomorphisms.

PRE-REQUIREMENTS none

SYLLABUS

Discrete mathematics and abstract algebra (16 hours + 12 hours of class tutorials):

1. *Set theory; natural numbers and the induction principle; permutation groups:* the symmetric group on n objects; representations of permutations, (properties of) cycles; decomposition of a permutation in a product of disjoint cycles; even and odd permutations; simplicity of the alternating group on 5 objects.
2. *Rings*: homo-, mono-, epi-, endo-, iso- and automorphisms of rings, (principal and maximal) ideals, quotient rings; isomorphism theorem; *polynomials*: construction of the ring of polynomials; degree of a non-zero polynomial; Euclidean division algorithm; factorization in the ring of polynomials; polynomial mappings; roots of a polynomial; Ruffini's theorem.
3. *Skew-fields and fields:* the fields of rational, real and complex numbers; fundamental theorem of Algebra; construction of the skew-field of quaternions.
4. *Finite fields*: construction and properties of finite fields.

Linear algebra (16 hours + 12 hours of class tutorials):

1. Vector spaces and linear mappings: vector spaces over fields, linear (in-) dependence, bases and dimension, subspaces and quotient spaces; direct sums, Grassmann's formula, linear mappings: homo-, mono-, epi-, endo-, iso- and automorphisms of vector spaces.

2. Matrices: operations between matrices; rank of a matrix; triangular matrices; elementary operations, equivalent matrices; matrices and linear mappings, characterization of linear mappings between vector spaces, change of bases; inverse matrices.

3. Determinants: definitions; calculus of the determinant using Laplace's formula; Binet's theorem; applications of determinants.

4. Systems of linear equations: the Rouché-Capelli theorem; use of determinants; Cramer's rule; normal form

of systems; the Gauss-Jordan method. Geometric interpretation of the sets of solutions.
5. Eigenvalues and eigenvectors: characteristic polynomial of an endomorphism; criteria for the existence of a basis of eigenvectors.

TEACHING METHODS

The course is articulated in 56 hours of teaching, i.e. 32 hours of theoretical lessons and 24 hours of classroom tutorials.

EVALUATION METHODS

The final assessment considers the students' achievements concerning the educational goals listed above. It is organized as an written examination (2 hours time), where the student shows comprehension of the arguments treated in the lessons and ability to solve problems numerically. The assessment consists in four exercises, namely the solution of a system of 3 linear equations in 3 unknowns depending on a parameter (12 points) and three exercises (6 points each) concerning properties of functions and operations, inverse matrices and bases of eigenvectors. To pass the examination, it is necessary to obtain at least 15 points. Student may consult books and classroom notes as well as a calculator, but must not use a PC or a smartphone.

TEXTBOOKS AND ON-LINE EDUCATIONAL MATERIAL

Text books:

- MacLane, Birkhoff: *Algebra,* AMS Chelsea 1999
- Childs: *A Concrete Introduction to Higher Algebra,* Springer UTM 1984
- Lipschutz: Linear *Algebra ,* Schaum's Outline Series, McGraw-Hill 1974

Further reading concerning arguments of abstract algebra:

- Jacobson, *Basic Algebra I*, Freeman, New York 1980

Teacher's classroom notes available on the website of the course: http://informatica.unibas.it/moodle/

INTERACTION WITH STUDENTS

At the beginning of the course, the teacher explains goals and methods of the course.
Students are received each Friday from 11 a.m. to 1 p.m. (as well as on appointments taken by e-mail) at the teacher's office (Room n. 53 of the Dept. DiMIE).

EXAMINATION SESSIONS (FORECAST)[1]

20-Feb-2020, 21-May-2020, 25-Jun-2020, 16-Jul-2020, 24-Sep-2020, 17-Dec-2020

SEMINARS BY EXTERNAL EXPERTS YES □ NO X

FURTHER INFORMATION

[1] Subject to possible changes: check the web site of the Teacher or the Department/School for updates.