UNIVERSITÀ DEGLI STUDI DI BARI ALDO MORO

CONSIGLIO INTERCLASSE IN MATEMATICA

COURSE OF STUDY TWO-YEAR MASTER OF SCIENCE PROGRAMME IN MATHEMATICS

ACADEMIC YEAR 2023-2024

ACADEMIC SUBJECT ELEMENTS OF ADVANCED GEOMETRY

General information	
Programme year	First
Term	Second semester (February 26, 2024 – May 31, 2024)
European Credit Transfer and Accumulation System credits (ECTS)	7
SSD	MAT/03 – Geometry
Language	Italian
Mode of attendance	Not mandatory

Lecturers		
Name and surname	Francesco Bastianelli (instructor of record)	Mauricio Barros Correa Junior
E-mail	francesco.bastianelli@uniba.it	mauricio.barros@uniba.it
Telephone	+39 080 544 2664	+39 080 544 2655
Department and office	Department of Mathematics room 18 second floor	Department of Mathematics room 6 second floor
Virtual meeting room		
Web page	https://sites.google.com/site/francescobastianelli/	https://www.dm.uniba.it/it/members/correa
Office hours	in order to schedule an appointment, please contact the lecturer by email.	in order to schedule an appointment, please contact the lecturer by email.

Work schedule	Total	Lectures	Hands-on learning (recitations)	Self-study
Hours	175	40	30	105
ECTS credits	7	5	2	

Learning objectives	
	Learning basic notions of algebraic topology and some basic tools of modern geometry, concerning in particular the fundamental group of a topological space, sheaf theory, omology and cohomology of a differentiable manifold.

Course prerequisites	
	Mathematical knowledge which is usually learned during the first two years of a degree in Mathematics (class L–35). In particular, classical analysis of one and several variables, linear algebra, affine and projective geometry, general topology. Basic theory of differentiable manifolds, which is usually learned during the third year of a degree in Mathematics (class L–35). In particular, notion of differentiable manifold, tangent and cotangent space to a differentiable manifold at a point, differential forms on a differentiable manifold.

Syllabus

Course contents	**1. Elements of category theory:** categories, isomorphisms, functors. **2. Fundamental group and covering spaces:** homotopy, fundamental group, functorial properties of the fundamental group, covering spaces, liftings, theorem of Seifert–Van Kampen, applications. **3. Complexes, homology and cohomology:** exact sequences of abelian groups, chain complexes, morphisms of complexes, homology groups, exact sequences of complexes, induced long exact sequence of homology groups, homotopy of complexes, dual complexes and cohomology. **4. De Rham cohomology:** cochain complexes, cohomology groups, the de Rham complex and its cohomology, Poincaré lemma. **5. Singular homology and singular cohomology:** singular simplexes and singular chains, singular homology, singular cohomology, the Mayer–Vietoris sequence and applications. **6. Elements of sheaves theory:** presheaves and sheaves of abelian groups, morphism of presheaves, stalk of a presheaf, sheaf associated to a presheaf, exact sequences of sheaves. **7. Cohomology of sheaves:** resolutions of sheaves, soft sheaves and canonical resolutions, cohomology groups of a sheaf, acyclic sheaves, de Rham theorem.
Reference books	M. Abate, F. Tovena, *Geometria differenziale*, Springer. W. Fulton, *Algebraic topology*, Springer. C. Kosniowski, *A first course in algebraic topology*, Cambridge University Press. M. Manetti, *Topologia*, Springer. I. Madsen, J. Tornehave, *From calculus to cohomology*, Cambridge University Press. E. Sernesi, *Geometria 2*, Bollati Boringhieri. R. O. Wells, *Differential analysis on complex manifolds*, Springer.
Additional course materials	Further information will be available at the webpage https://sites.google.com/site/francescobastianelli/teaching and further materials will be uploaded on Microsoft Teams (team code: 6gmr2z2)
Repository	

Expected learning outcomes	
Knowledge and understanding	Assimilating fundamental concepts in modern geometry and of elementary algebraic topology. Assimilating the related techniques.
Applying knowledge and understanding	The assimilated theoretical knowledge is involved in large part of geometry and its applications.
Soft skills	*Making judgements*: ability to analyze the consistency of the logical arguments appearing in a proof.
	Communication skills: students should learn the mathematical language and formalism necessary to read and comprehend textbooks, to explain the assimilated knowledge, and to describe, analyze and solve problems.
	Learning skills: assimilate suitable learning methods, supported by consulting textbooks and by solving the exercises and questions which are periodically proposed during the course.

Teaching methods

	Lectures and exercise classes.

Assessment	
Assessment methods	Oral exam about the topic of the course, to evaluate the understanding of the themes investigated.
Evaluation criteria	• *Knowledge and understanding:* quality and accuracy of the techniques, of the proofs, and of the abstract reasoning based on the topic of the course. • *Applying knowledge and understanding:* ability of apply the techniques and the notions presented in the course in order to solve concrete geometric problems. • *Making judgements:* ability of deciding the accuracy of a formal reasoning and ability of choosing suitable techniques for solving a problem. • *Communication skills:* quality and accuracy of the acquired knowledge and of the reasoning skills. • *Learning skills*: organization of knowledge, critical reasoning, possible additional study of the topics related to the course.
Grading policy	The final assessment is given in the range 18/30 – 30/30 e lode. The exam is passed if the assessment is greater than or equal to 18/30. It depends on the completeness, the quality, the accuracy and the precision showed during the exam, concerning the acquired knowledge and ability.

Further information	
	Attending classes is strongly recommended.