Basic/Essential Course Information	
Course title	GEOMETRY
Degree Course title	Physics
ECTS	
Compulsory attendance	Yes
Course teaching language	ITALIAN

Teacher	Giulia Dileo	Giulia.dileo@uniba.it

ECTS Details	Disciplinary area/broad field:	SSD	ECTS
	c	MAT/03	9

Time management and teaching activity type	Period	Year	lesson type
	1st semester	1st	Lessons (56h) Exercises (30h)

Time management,	Total ho	in-class/in-lab study hours	out-of-class study hours
	225	86	139

Course calendar	Starting date	Ending date
	24.09.2018	19.12.2018

Syllabus	
Prerequisites	Basic mathematical knowledge: polynomials, first and second degree equations and inequalities, fundamental theorems of Euclidean geometry, elements of trigonometry, elements of analytic geometry in dimension 2.
Expected learning outcomes (according to Dublin Descriptors)	**Knowledge and understanding of:** Acquiring fundamental concepts in linear algebra, dealing with vector spaces, linear maps and scalar products, and the basics of affine and Euclidean geometry. Acquiring basic mathematical proof techniques. **Applying knowledge and understanding:** The acquired theoretical knowledge is applied in solving problems in linear algebra and geometry, where students are particularly concerned with matrix calculus, systems of linear equations, diagonalization of endomorphisms or matrices, and the description of subspaces (linear, affine or Euclidean) through parametric or Cartesian equations. **Making judgements:** Ability to analyze the consistency of the logical arguments used in a proof. Problem solving skills should be supported by the capacity in evaluating the consistency of the found solution with the theoretical knowledge. **Transferable Communication skills:** Students should acquire the mathematical language and formalism necessary to read and comprehend textbooks, to explain the acquired knowledge, and to describe, analyze and solve problems. **Lifelong learning skills:** Acquiring suitable learning methods, supported by text consultation

	and by solving the exercises and questions periodically suggested during the course.
Course contents summary	Linear algebra. Affine and Euclidean geometry.
detailed syllabus	**Basic set theory.** Union and intersection of sets, complement of a set, the powerset of a set. Ordered pairs and n-tuples. Cartesian product. Relations. Order relations. Equivalence relations, equivalence classes and quotient set. Functions. Image and preimage of sets. Surjective, injective and bijective functions. Function composition. Inverse function. **Algebraic structures.** Binary operations. Associativity, commutativity, identity element and inverses. Groups and subgroups. Rings. Fields and subfields. Complex numbers and field structure. Conjugate and modulus of a complex number. Polynomial ring in x over a field K. Properties of polynomials. **Vector spaces.** Vector spaces, properties and examples. The space of geometric vectors. Linear subspaces. Intersection, sum and direct sum of subspaces. Supplementary subspaces. Linear combinations of vectors. Vector space spanned by n vectors. Finitely generated vector spaces and systems of generators. Linearly dependent and linearly independent vectors. Bases. Components of a vector with respect to a basis. Existence of bases: procedure to find bases. Dimension of a finitely generated vector space. Dimension of linear subspaces. Extension of linearly independent vectors to a basis. Grassmann identity. **Matrices and systems of linear equations.** The vector space of matrices with m rows and n columns over a field K. The transpose of a matrix. Square matrices, symmetric, skew-symmetric, diagonal, and scalar matrices. Trace of a square matrix. Matrix product. Determinant of a square matrix: definition and properties. Invertible matrices and inverse matrix. The group GL(n, K) and its subgroups. Orthogonal matrices. Rank of a matrix: definition and properties. Matrix associated to a set of vectors with respect to a basis. Change of basis matrix. Systems of m linear equations in n variables. Cramer's systems. Rouché-Capelli theorem. Homogeneous systems. General method for finding the solution set of a linear system. **Linear maps.** Linear maps between vector spaces. Characterization and properties. Kernel and image of a linear map. Characterizations of surjective or injective linear maps. Existence and uniqueness of linear maps. Isomorphisms. Matrices associated with a linear map. Eigenvectors, eigenvalues and eigenspaces of an endomorphism. Diagonizable endomorphisms: definition and characterization. Similar matrices. Diagonalizable matrices. Characteristic polynomial. Algebraic and geometric multiplicity of an eigenvalue. Criterion of diagonalizability of endomorphisms. **Euclidean vector spaces.** Orientation of a real vector space. Euclidean vector spaces. Scalar product. Standard scalar product on R^n. The norm of a vector. Convex angle between two non-zero vectors. Parallel vectors. Orthogonal vectors. Systems of orthogonal vectors. Orthonormal bases. Change of orthonormal basis matrix. Gram-Schmidt theorem. Orthogonal complement of a linear

	subspace. Unitary operators: definition, characterization and examples. Unitary operators and orthogonal matrices. Self-adjoint operators. Self-adjoint operators and symmetric matrices. The characteristic polynomial of a symmetric real matrix. Spectral theorem. **Affine Spaces.** Affine space associated to a vector space. Affine frames and coordinate systems. Affine subspaces and their direction. Affine subspace generated by k points. Affinely independent points. Parametric and cartesian equations of an affine subspace. Parallel subspaces. Intersection of affine subspaces. Change of affine frames. Affine geometry in dimension 2. Coordinate axes. Parametric equations and cartesian equation of a line. Parallel lines and intersection of lines. Affine geometry in dimension 3. Coordinate axes and planes. Parametric and cartesian equations of a plane. Parametric and cartesian equations of a line. Parallel lines. Parallelism between a line and a plane. Parallelism between planes. Coplanar lines. Sheaves of planes. **Euclidean spaces.** Euclidean space associated to a Euclidean vector space. Cartesian frames and cartesian coordinates. Change of cartesian frames. Distance between two points. Convex angle between two lines. Orthogonal lines. *Euclidean geometry in dimension 2.* Orthogonal lines. Distance between two points. *Euclidean geometry in dimension 3.* Orthogonal lines, orthogonality between a line and a plane, orthogonality between two planes. Distance between a point and a plane. Distance between two points. Minimum distance between lines. Equation of a sphere. *Isometries of a Euclidean space of dimension n.* Definition, characterization and geometric properties of isometries. Equations of an isometry with respect to a cartesian frame. Examples: translations and rotations. Euclidean conics. Equation of a conic. Canonical form of a Euclidean conic. Hints on Euclidean quadrics.
books	E. Sernesi, Geometria 1, Bollati Boringhieri. E. Abbena, A.M. Fino, G.M. Gianella, Algebra lineare e geometria analitica, Aracne. Facchini, Algebra e Matematica Discreta, Zanichelli.
notes	
Teaching methods	Lectures and exercise sessions.
Assessment % of final mark	Oral exam.
Evaluation criteria	the student • **knows** the fundamental concepts in linear algebra: vector spaces, linear maps, scalar products; • **knows** the fundamental concepts in affine and Euclidean geometry; • **knows and knows how to use** matrix calculus, in order to solve systems of linear equations, and diagonalize endomorphisms or matrices; • **knows and knows how to derive** parametric and cartesian

	equations of subspaces (linear , affine or Euclidean), describing relative properties; • **knows how to prove** a proposition, presenting the proof in suitable mathematical language and formalism.
other	