FISICA MATEMATICA I

MAT/07 - 6 CFU - 2° Semester

Teaching Staff

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LEARNING OBJECTIVES

The course has as main objective the theoretical treatment of classical mechanics allowing the student to connect the topics of the course with the concepts learned in Calculus I, Calculus II, Geometry I and General Physics I.

With this course the student will acquire the basic knowledge for:
The study of holonomic systems with particular regard to the kinematics and dynamics of rigid bodies.
Elements of Analytical Mechanics.

In particular, in reference also to the so-called "Dublin Descriptors", the course will aim to achieve the following transversal skills:

1) Knowledge and understanding:
One objective of the course shall be provide mathematic instruments, such as theorems and algoritms, which permit to face real problems in applied mathematics, physics, informatics, chemistry, economy and many other fields. With these mathematical instruments, student gets new abilities to clear useful theoretical and application problems.

2) Applying knowledge and understanding:
At the end of course student will be able to get new mathematical techniques of knowledge and understanding to face all possible links moreover, if it is possible, they will propose untreated new problems.

3) Making judgements:
Course is based on logical-deductive method which wants to give to students authonomus judgement useful to understanding incorrect method of demonstration also, by logical reasoning, student will be able to face not difficult problems, in applied mathematics, with teacher's help.

4) Communication skills:

In the final exam, student must show, for learned different mathematical techniques, an adapt maturity on oral communication.

5) Learning skills:
The Students must acquire the skills necessary to undertake further studies (master's degree) with a high degree of autonomy. The course in addition to proposing theoretical arguments presents arguments which also should be useful in different working fields.

COURSE STRUCTURE

The lessons will be held through classroom. In these lessons the program will be divided into the following sections: Vectorial and tensorial algebra; Kinematics; Dynamics. In each of these sections first it will be discussed the main theoretical topics and then showed how these topics can be linked to possible applications. Then, many exercises are presented and discussed to identify solutions and applications on topics related to theoretical results.

The course is composed by 6 CFU of which:
5 CFU (corresponding to 7 hours each) are dedicated to theoretical lessons in the classroom for a total of 35 hours, e
1 CFU (corresponding to 12 hours) are dedicated to classroom exercises.
The course, of 6 CFU, therefore includes a total of 47 hours of teaching activities.

DETAILED COURSE CONTENT

Vectorial and tensorial algebra:

Vector spaces, dimensions and bases of a vector space. Pseudo-Euclidean and Euclidean spaces. Metric tensor, covariant and contravariant components. Coordinates Cartesian, polar, spherical and Cylindrical. Coordinate changes. Curvilinear coordinates. calculus scalar and vector products, mixed products. Tensorial Algebra. Covariant, contravariant and mixed components of a tensor. Vector fields in physics.

Kinematics:
Particle kinematics. Motion, velocity and acceleration of a point particle: plane, circular, harmonic and helical motions. Curvilinear abscissa. Intrinsic systems of references. Frénet formulas. Kinematics of rigid bodies. Poisson's formulas and angular velocity. Analysis of the field of velocity of a rigid body. Different kinds of rigid motions. Plane rigid motions. Rigid body with a fixed point. Rigid body with a fixed axis. Mechanics of rigid bodies, some applications. Relative kinematics. Composition of the velocities, of the accelerations and of the angular velocities. Galileian equivalence. Inertial frames and Galilei transformations. Inertial and not inertial systems of references. Coriolis theorem. Fictitious forces. Coriolis forces. Euler angles.

Dynamics:
Axioms of classical dynamics. Statics and the dynamics of a particle. Statics and the dynamics of a system. Cardinal equations in static and in dynamics. Conservation theorems. Rigid-body dynamics. Centers of mass and moments of inertia. Inertia tensor, principal axes. Principal moments of inertia. Properties of the inertia tensor. Huygens and Steiner's theorems. Koenig's theorem for the kinetic energy. Kinetic energy and angular momentum of a rigid body. Potential energy. Constraints. Holonomic and non-Holonomic constraints for physical systems. Generalized coordinates and degrees of freedom.

Configuration space. Bilateral and unilateral constraints. Reversible and irreversible displacements. Ideal constraints. Possible and virtual displacements. Principle of virtual work. Principle of d'Alembert. Lagrangian and Lagrange equations. Conservative force fields and potentials. Conservation of energy. Generalized potentials and applications. Integrals of motion. Equilibrium positions. Stability of equilibrium positions. Lyapunov theorem. Dirichlet Stability Theorem. Small oscillations around stable equilibrium points.

TEXTBOOK INFORMATION

1. Teacher's notes.
2. S. Rionero, Lezioni di Meccanica razionale, Liguori Editore.
3. Strumia Alberto, Meccanica razionale. Vol. 1 e Vol. 2, Ed. Nautilus Bologna
(http://albertostrumia.it/?q=content/meccanica-razionale-parte-ii)
4. Strumia Alberto, Complementi di Meccanica Analitica
(http://albertostrumia.it/?q=content/meccanica-razionale-parte-ii)
5. H. Goldstein, Meccanica classica, Zanichelli, Bologna.
