FISICA MATEMATICA II

MAT/07 - 6 CFU - 1° Semester

Teaching Staff

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LEARNING OBJECTIVES

The course has as main objective the theoretical treatment of classical mechanics through the study of Analytical Mechanics. The course allows the student to connect the topics covered with the concepts learned in Calculus I, Calculus II, Geometry I, General Physics I and Mathematical Physics I.

The course of "Mathematical Physics II" aims to complete the program carried out in the course of "Mathematical Physics I".The course pursues as main objective is to treat classical mechanics, with more advanced mathematical tools such as modern methods variational. Within this approach, the equations of motion for a generic physical system will therefore be derived, starting from considerations geometric and symmetry properties of space-time, using general variational principles both in the space of the configurations that in the phase space. With this course will be analyze the deep connection between the geometric properties of a given physical system and the laws of physics that govern it. The variational principles have been, and are at present, the essential tools for the description of modern physics (classical and non-classical).

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:
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: Short Connections with the Mathematical Physics I course; Analytical Mechanics. 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

Brief summary and links with the course of Mathematical Physics I:
Vectorial and tensorial algebra. Notions introduced on the configuration space

Analytical Mechanics:
Variational principles and the Lagrange equations. Configuration space. Tangent vectors and tangent space. Variational principle and Hamilton principle in the Configuration space. Principle of the least action and the Lagrange equations. Cyclic variables. Geodetic calculations. The brachistochrone problem. Conserved quantities and Noether theorem. Two-body problem. Phase space. Hamiltonian Formalism. Legendre transformations. Hamilton equations. Derivation of Hamilton equations from a Variational principle. Application of Hamiltonian methods to various problems. Canonical transformations. Generating function of a canonical transformation. Applications and examples. The theory of Hamilton-Jacobi. Derivation of Hamilton-Jacobi equation from a Variational principle. Equation of Hamilton-Jacobi and its application. Variable separation in the method of Hamilton-Jacobi. Poisson brackets. Poisson theorem. Applications and examples.

Variational principles in the theory of electromagnetic fields (*):

Introduction to the theory of special relativity. 4-dimensional formalism. Event as a point in spacetime. Non-Euclidean and Minkowski metrics. Types of 4-intervals. Contraction of lengths and time dilations. Lagrangian formulation and equations of motion deduced from variational principles.Variation of a functional in fields theory. Tensor of the Electromagnetic Field. Gauge invariance and its connection with potentials generalized. Invariants of the Electromagnetic Field. Construction of the Lagrangian function using the representation theorems for scalar functions of the Lorentz group. General formulation for the linear and nonlinear Maxwell equations, microscopic interpretation, experimental verification.

(*) This part of the program (or part of it) will be carried out compatibly with the total number of hours of the course

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TEXTBOOK INFORMATION

1. Teacher's notes.
2. S. Rionero, Lezioni di Meccanica razionale, Liguori Editore.
3. Strumia Alberto, Complementi di Meccanica Analitica (http://albertostrumia.it/?q=content/meccanica-razionale-parte-ii)
4. H. Goldstein, Meccanica classica, Zanichelli, Bologna.
5. L.D. Landau E. M. Lifsits, Fisica teorica. Vol. 1: Meccanica, Editori Riuniti.
6. Valter Moretti, Elementi di Meccanica Razionale, Meccanica Analitica e Teoria della Stabilità. (http://www.science.unitn.it/~moretti/runfismatI.pdf)
7. L.D. Landau E. M. Lifsits, Fisica teorica. Vol. 2: Teoria dei campi, Editori Riuniti.
