MATHEMATICAL PHYSICS

MAT/07 - 12 CFU - 1° Semester

Teaching Staff

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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.

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.

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. A.Fasano, V.De Rienzo, A.Messina, Corso di Meccanica Razionale, Laterza, Bari.
6. H. Goldstein, Meccanica classica, Zanichelli, Bologna.
7. L.D. Landau E. M. Lifsits, Fisica teorica. Vol. 1: Meccanica, Editori Riuniti.
8. Valter Moretti, Elementi di Meccanica Razionale, Meccanica Analitica e Teoria della Stabilità. (http://www.science.unitn.it/~moretti/runfismatI.pdf)
