UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2023/2024
BACHELOR'S DEGREE (BSC)	CYBERNETIC ENGINEERING
INTEGRATED COURSE	ANALYTICAL MECHANICS AND ELECTROMAGNETISM - INTEGRATED COURSE
CODE	22431
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	MAT/07, FIS/01
HEAD PROFESSOR(S)	LO FRANCO ROSARIO Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	GARGANO FRANCESCO Professore Associato Univ. di PALERMO LO FRANCO ROSARIO Professore Associato Univ. di PALERMO
CREDITS	12
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	2
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**GARGANO FRANCESCO** Tuesday 10:00 11:00 Ex dipartimento di Metodi e modelli Matematici, primo piano **LO FRANCO ROSARIO** Thursday 15:00 17:00 (i) Ufficio del docente. Viale delle Scienze, Edificio 6, secondo piano, stanza 214; (ii) online sulla piattaforma istituzionale Microsoft Teams.

DOCENTE: Prof. ROSARIO LO FRANCO

PREREQUISITES	Knowledge of the basics concepts of calculus and mathematical analysis, derivation and integration in one and more variables functions, vectorial spaces, Euclidean spaces, linear algebra, matrix algebra, classical kinematics laws for a material particle, Newton's laws, forces, work and energy, main laws of thermodynamics.
LEARNING OUTCOMES	Knowledge and Comprehension: the students, at the end of the course, will have learned how to build a physical model for the description of complex mechanical system, and for the description of phenomena in which electric and magnetic forces are involved. In particular, the students will gain knowledge of the methodology adopted to build a model for the motion of a rigid body and for its equilibrium through the cardinal equations and the virtual work principle, to determine the main parameters characterizing the spatial configurations, and to derive the laws governing the dynamics of a material system; moreover they will gain knowledge of the electrostatic field: charge, electric field, electrostatic potential, Coulomb's law, Gauss theorem, energy of the electrostatic field, electric dipole, capacitors and dielectrics. Moreover, the students will have understood the importance of Kirchhoff's laws for the study of electrical circuits. They will have also awareness of magnetism: magnetic field, Lorentz force, Ampere's law, BiotSavart relation, electromagnetic induction (Faraday-Lenz law), energy of the magnetic field, diamagnetism, paramagnetism and ferromagnetism. Finally, the students will have understood the importance of Maxwell's equations as an essential tool for the description and quantification of each electrical phenomenon and / or magnetic observable in classical physics. In particular, through the study of electromagnetic waves and their equation, obtained directly from the Maxwell's equations, the students will have known the electromagnetic nature of light and radio waves. Ability to apply knowledge and comprehension: The student will be able to identify the symmetries in a physical problem, schematize the mechanical and electromagnetic phenomena for their quantitative description, identify the variables needed to build a physical model. Moreover, the students will have also the ability to apply the laws of the mechanical systems and electromagnetism to concrete situations in order to solve simple problems concerning the equilibrium and the dynamics of a system through the cardinal equations, and problems concerning electric and magnetic phenomena, using symmetry arguments, the superposition principle and the conservation laws, the Maxwell equations. Making judgments: The student will be able to determine if in a given problem should be used a "dynamic" approach (analysis of the system in terms of inertial, electric and magnetic forces) or, otherwise, an "energetic" approach (analysis of the system through the application of principle of energy conservation or the minimization of the potential energy), also in real life problems. Communicative skills: The student will acquire the ability to exhibit consistently and with language properties the course contents, referring to Mechanical systems and Electromagnetism by making qualitative considerations on specific problems and creating links to the main principles and laws. The students will have gained expertise to work in group by sharing ideas for solving specific problems. Learning ability: The student will have refined the abilities to examine books and scientific papers to find concrete applications of the laws and principles studied. This will allow to the student to continue his engineering studies with greater intellectual independence and increased capability in operating assessments and making decisions.
ASSESSMENT METHODS	The final test aims to assess whether the student has knowledge and understanding of the topics and has acquired the ability to apply this knowledge. The final test consists of a written test and an oral test. The written test requires the solution of two exercises for the Analytical Mechanics module and two exercises for the Electromagnetism module, referring to all parts of the program and always conform to the examples and exercises developed during the course. Books and notes of the course cannot be used during the written text, while the use of a calculator is allowed. The oral test consists of an exam where the candidate will have to answer at least two or three questions, on all parts of the program, with reference to the recommended texts; as well as a critical discussion on the performance of the exercises proposed in the written test. The overall assessment will be made on the basis of the following criteria. The

	final test will be judged: - Inadequate: if the candidate does not have an acceptable knowledge of the topics covered in the teaching; - Sufficient (rating 18-21): If you have a basic understanding of the object of teaching subjects but an insufficient ability to use independently the acquired knowledge; - Satisfactory (rating 22-25): if it has not fully mastered the topics covered but has sufficient capacity 'of independent use of the knowledge gained; - Good (score 26-28): if you have a good command of the object of teaching topics, has a discrete property of language and demonstrates a sufficient ability 'to independently apply the knowledge acquired; - Excellent (score 29- 30 cum laude): if it demonstrates excellent knowledge and mastery of the laws of analytical mechanics and relativistic, excellent property 'language and if it is able to apply autonomously the acquired knowledge to solve problems It will be possible, for the students requiring this, to perform the test for only one of the two modules of the course (Analytical mechanics or Electromagnetism) and subsequently to perform the text for the remaining module whithin the established scheduling of the academic year. Each single text will contain only the arguments of that specific module. The written text will contain two exercises concerning the arguments of the specific module to be solved within a duration of 1 hour and 30 minutes, while the oral test is subsequent the written text. The final rating will be the average for excess of the two ratings obtained in each module.
TEACHING METHODS	Lectures and practice exercises in class.

MODULE
RATIONAL MECHANICS (*)

Prof. FRANCESCO GARGANO

SUGGESTED BIBLIOGRAPHY

Libri di testo /textbooks:

• Fabio Bagarello, Meccanica razionale per l'ingegneria ,
Mc Graw Hill. ISBN: 9788838672958

• Biscari, Ruggeri, Saccomandi, Vianello, Meccanica Razionale, 3 Edizione,
Springer, Unitext, ISBN: 9788847057722

• Brini, Muracchini, Ruggeri, Seccia, Esercizi e temi d'esame di meccanica
razionale, 5a Edizione, Società Editrice Esculapio, ISBN 9788893851183

• E. Di Benedetto. Classical Mechanics: Theory and Mathematical Modeling,
Springer, ISBN 978-0-8176-4648-6

AMBIT	50283-Matematica, informatica e statistica
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

At the end of the course, the student will acquire knowledge on the fundamental principles
of mechanics that govern the kinematics and dynamical equilibrium of a complex material system. In particular, the student will be able to understand the problems that arise from the need to create a rigorous language using the logical-deductive method to tackle physical-mathematical problems inherent to the topics of the module. The student will also be able to understand the problems deriving from the mechanics of complex systems that can be framed in the typical technologies of cybernetic engineering, and to represent and contextualize them in the appropriate mathematical language. These objectives are in line with the aims of the educational objectives of the Course of Studies in Cybernetics, that forms and engineer having expertise in defining, formulating and solving problems that require an interdisciplinary approach with the rigorousness of the scientific method.

SYLLABUS

Hrs	Frontal teaching
3	Definition of applied vectors system. Resultant and momentum of a system. Law of the variation of the momentum. couple of applied vectors. Torsor. Reducibility and equivalence of a system. Basic operation on a system. Poisson's theorem on the reducibility. Trinomial invariant and reduction to torsor. Center of parallel applied vectors. Kinematics of a material point. Equation of the motion. Scalar and vectorial Velocity and acceleration.
2	Kinematics of a material point. Equation of the motion. Scalar and vectorial Velocity and acceleration. Curve on the space. Curvilinear abscissa. Frenet's Trihedron. Curvature and osculating circle. Central motion and Binet law, areolar velocity.
4	Kinematics of rigid bodies. Absolute and solidal axes. Fundamental law of a rigid motion and Poisson formulas. Planar motion. Instantaneous center of zero velocity and acceleration. Mozzi’s theorem a local motion in time
3	Kinematics of relative motion for a point. Velocity and acceleration in absolute and relative system. Galileo's principle and Coriolis theorem. Relative motion of rigid bodies, composition of angular velocity.
3	Constraint and friction, classification of the constraints and their reaction. Coulomb- Morin Laws. Motion of a material point constrained on a curve and surface. Rigid Contact motion over curve and surfaces. Conditions for a pure rolling and slipping
4	Material system. Gravity center and its properties. Moment of inertia. Operator and tensor of inertia.
3	Work and conservative forces. Potential and Potential energy. Work of a rigid body. Definition of infinitesimal work, possible work, virtual work, elementary work. Power. Work of a solicitation acting over a rigid body.
7	Static of a material system. Virtual displacements and constraints. Principle of virtual work. Work of the virtual reaction. Equilibrium of material systems.

3	Dynamics of a material system. Quantity of motion and constraints. Momentum of the quantity of motion. Kinetic energy. Koenig's theorem. Orbital angular momentum

Hrs	Practice
2	Systems of applied vectors.
4	Rigid bodies, slipping and pure roll motion
6	Geometry of masses.
10	Equilibrium of a material system. Constraint forces.

MODULE
PHYSICS 2

Prof. ROSARIO LO FRANCO

SUGGESTED BIBLIOGRAPHY

- P. Mazzoldi, M. Nigro, C. Voci, Fisica Vol. II, EdiSES
- P. Mazzoldi, M. Nigro, C. Voci, "Elementi di Fisica", Vol. II/2000, EdiSES
- S. Focardi, I. Massa, A. Uguzzoni, M. Villa, "Fisica Generale, Elettromagnetismo", II/2003, CEA,
- R.A. Serway, J.W. Jewett, "Fisica per Scienze ed Ingegneria, Volume 2", V/ 2015.
- D.J. Griffiiths, "Introduction to Electrodynamics", Fourth Edition, Cambridge University Press

Libri per ulteriori esercizi e problemi.

- M.Nigro, C. Voci, "Problemi di fisica generale. Elettromagnetismo -Ottica", Libreria Cortina.

AMBIT	50284-Fisica e chimica
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

The student will learn the phenomena in which there are electric forces and magnetic forces due to the distribution of charges, stationary currents, together with the ability to build an adequate physical model and to apply the laws of Coulomb, Gauss and Ampere to specific cases. The use of conservation principles, the laws of electrostatics and Ampere's law represents a fundamental objective not only to understand the meaning of charge, electric field, electric current and magnetic field, but also to understand the role played from these quantities into the functioning of the real world. The concept of electrostatic potential will also be introduced, with the aim of providing the student with an essential conceptual tool for the description of an electrostatic system in terms of energy variations. The student will learn to deal with physical situations in which stationary charges or steady currents are present, to describe qualitatively what is happening in the considered system.

The student will understand the phenomena and laws related to time-varying electric and magnetic fields. Through the study of electromagnetic induction (Faraday-Lenz law) and displacement currents (Maxwell's law of induction) the student will be able to deal with systems in which there are fields that vary in time and space, understanding the electromagnetic nature of light and learning to qualitatively describe the phenomena present in a given system.

Finally, by choosing the appropriate tools to quantitatively analyze the dynamics of the system under study, he will be able to solve the equations to obtain the mathematical solution of the problem posed. The comparison between the physical aspect of the problem, qualitatively discussed, and the mathematical description obtained will allow the student to have a complete understanding of the phenomenon considered.

SYLLABUS

Hrs	Frontal teaching
5	TOPIC 1 - ELECTROSTATICS. Electric charges. Insulators and conductors. Electrical structure of matter. Coulomb's law. Electrostatic field. Electrostatic field produced by a continuous distribution of charges. Lines of force of the electrostatic field. Motion of a charge in an electrostatic field. Flux of the electrostatic field. Gauss's law. The divergence of the electrostatic field.
4	TOPIC 2 - ELECTROSTATIC POTENTIAL. Voltage and potential. Electrostatic potential energy. The electric field as a potential gradient. Equipotential surfaces. The rotor of the electrostatic field. The electric dipole. The force on an electric dipole.
4	TOPIC 3 - CONDUCTORS AND DIELECTRICS. Conductors in equilibrium. Hollow conductor. Electrostatic screen. Capacitors. Connection of capacitors. Energy of the electrostatic field. Dielectrics. The dielectric constant. Polarization of dielectrics.

4	TOPIC 4 - ELECTRICAL CURRENT. Electric conduction. Electric current. Stationary electric current. Ohm's law. Resistors in series and parallel. Kirchhoff's laws. Charging and discharging of a capacitor through a resistor.
2	TOPIC 5 - MAGNETIC FIELD. Magnetic interaction. Magnetic field. Magnetic force on a moving charge. Magnetic force on a current-carrying conductor. Mechanical moments on plane circuits. Hall effect. Motion of a charged particle in a uniform magnetic field.
2	TOPIC 6 - SOURCES OF THE MAGNETIC FIELD. Magnetic field produced by a current. Electrodynamic actions between current-carrying wires. Ampere's law. Gauss's law for magnetism.
4	TOPIC 7 - ELECTRICAL AND MAGNETIC FIELDS VARIABLE OVER TIME. Faraday's law. Induced electric field. Self-induction, RL circuits. Magnetic energy. Mutual induction.
3	TOPIC 8 - MAXWELL EQUATIONS AND WAVES. Displacement current. Ampere-Maxwell's law. Maxwell's equations. The Maxwell's equations in differential form. Elements of wave phenomena and electromagnetic waves. Wave equation obtained from Maxwell's equations.

Hrs	Practice
6	TOPIC 1 - ELECTROSTATICS.
3	TOPIC 2 - ELECTROSTATIC POTENTIAL.
1	TOPIC 3 - CONDUCTORS AND DIELECTRICS.
4	TOPIC 4 - ELECTRICAL CURRENT.
3	TOPIC 5 - MAGNETIC FIELD.
2	TOPIC 6 - SOURCES OF THE MAGNETIC FIELD
5	TOPIC 7 - ELECTRICAL AND MAGNETIC FIELDS VARIABLE OVER TIME.
2	TOPIC 8 - MAXWELL EQUATIONS AND WAVES.