UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2019/2020
MASTER'S DEGREE (MSC)	ELECTRONICS ENGINEERING
SUBJECT	QUANTUM PHYSICS AND APPLICATIONS
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20925-Attività formative affini o integrative
CODE	20518
SCIENTIFIC SECTOR(S)	FIS/07
HEAD PROFESSOR(S)	BASILE SALVATORE Professore Associato Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**BASILE SALVATORE** Tuesday 15:00 17:00 Viale delle Scienze, Edificio 6 (ex DIN), stanza 213. Nel periodo di non svolgimento di attivita didattica in presenza si svolge su piattaforma Teams, previa prenotazione via email. Thursday 15:00 17:00 Viale delle Scienze, Edificio 6 (ex DIN), stanza 213. Nel periodo di non svolgimento di attivita didattica in presenza si svolge su piattaforma Teams, previa prenotazione via email.

DOCENTE: Prof. SALVATORE BASILE

PREREQUISITES	Good knowledge of Physics I, Physics II, Mathematics, as presented in the previous courses. Some knowledge of subjects such as distributions and integral transforms is considered useful.
LEARNING OUTCOMES	Knowledge and understanding Theoretical understanding: have a good understanding of the principles of modern physics (logical and mathematical structure, experimental support, and described physical phenomena) and their applications to engineering. Mathematical skills: be able to understand and master the use of the most commonly used mathematical methods. This will be verified during the written and oral test. Applying knowledge and understanding Problem solving skills: be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems. Be able to solve simple problems on quantum mechanics, nuclear physics and radiation-matter interaction, using first principles and conservation laws. Modelling: be able to identify the essentials of a process / situation and to set up a working model of the same; be able to perform the required approximations. This will be verified during the written and oral test. Making judgements Be able to identify the more effective way to the solution of modern physics problems using the fundamental laws and/or a conservation approach. Acquire an understanding of how electromagnetism laws are applicable to many fields, namely engineering. This will be verified during the oral test. Communications skills Be able to describe, analyse and solve modern physics problems using appropriate technical language and be able of written and oral communication on related subjects. Be able to describe the logical flowchart of problem solving. Be able to improve the group working skills. This will be verified during the oral test. Learning skills The student will learn the basic laws of modern physics and the typical methodology of the physical sciences, to be applied to engineering problems, critically and in an autonomous way. He will also improve the ability of autonomous learning. Be able to approach more advanced subjects through available resources (technical literature papers, websites), as well as any other sources of information relevant to future work. This will be verified during the oral test.
ASSESSMENT METHODS	The exam consists of both a written and oral test, evaluated on a 30 points scale. The final mark will take into account the outcome of both tests. Purpose of the tests: test the knowledge of the principles of modern physics and the ability to solve simple problems on quantum mechanics, nuclear physics and radiation-matter interaction, using first principles and conservation laws. Check the ability of modelling and identifying the essential elements of a problem. Type of tests: written test (problems and exercises with symbolic or numerical answer, open- or closed-ended); passing the written test (at least 18/30) gives access to the oral exam (discussion of the written test and questions on general topics and / or exercises with reference to the recommended texts). The oral examination must be undertaken in the same exam session (“appello”) of the written test. The written test is a closed book one. Only a calculator and a formula sheet are allowed. Duration of the written exam: no more than 3 hours. A mid-term test will be scheduled, aiming at the assessment of the short and medium term time stability of the cognitive process. EVALUATION CRITERIA MARK 28 to 30 - 30 with distinction LEARNING OUTCOMES ACHIEVEMENT Learning outcomes have been achieved to a very good/excellent level. The student demonstrates most or all of the following characteristics. KNOWLEDGE AND UNDERSTANDING Full/excellent knowledge, understanding and integration of principles, concepts, methods and techniques of the discipline APPLYING KNOWLEDGE AND UNDERSTANDING Extensive/excellent evidence of relevant and perceptive application of theoretical and technical knowledge for tackling and solving problems, with very good/excellent level of autonomy, effectiveness and originality. MAKING JUDGMENTS, COMMUNICATION SKILLS, LEARNING SKILLS

	Comprehensive/excellent evidence of logical, analytical and critical abilities for reaching appropriate judgments and decisions, even based on incomplete or complex information and data. Full/excellent ability to communicate knowledge, analyses and conclusions, with a very good/excellent level of clearness, fluency and correct use of language. Very good/excellent abilities of concepts reinterpretation and interdisciplinary connection, showing full evidence for autonomously undertaking further studies or professional activity. MARK 24 to 27 LEARNING OUTCOMES ACHIEVEMENT Learning outcomes have been achieved to a good level. The student demonstrates most or all of the following characteristics KNOWLEDGE AND UNDERSTANDING Good knowledge, understanding and integration of principles, concepts, methods and techniques of the discipline, with minor inaccuracies or errors APPLYING KNOWLEDGE AND UNDERSTANDING Good evidence of application of theoretical and technical knowledge for tackling and solving problems, with fine/adequate level of autonomy and effectiveness. MAKING JUDGMENTS, COMMUNICATION SKILLS, LEARNING SKILLS Good/adequate evidence of logical, analytical and critical abilities for reaching appropriate judgments and decisions, based on available information and data. Good ability to communicate knowledge, analyses and conclusions, with a good level of clearness, fluency and correct use of language.EVALUATION CRITERIA Good/adequate abilities of concepts reinterpretation and interdisciplinary connection, showing evidence for autonomously undertaking further studies or professional activity. MARK 18 to 23 LEARNING OUTCOMES ACHIEVEMENT Learning outcomes have been achieved to an acceptable/basic level. The student demonstrates most or all of the following characteristics KNOWLEDGE AND UNDERSTANDING Acceptable/basic knowledge and understanding of principles, concepts, methods and techniques of the discipline, even if with some inaccuracies, errors or omissions APPLYING KNOWLEDGE AND UNDERSTANDING Evidence of adequate/basic application of theoretical and technical knowledge for tackling and solving problems, even if with limited level of autonomy and effectiveness. MAKING JUDGMENTS, COMMUNICATION SKILLS, LEARNING SKILLS Evidence of some logical, analytical and critical abilities for coherent judgments and decisions attempts. Basic ability to communicate knowledge, analyses and conclusions, with an acceptable level of clearness, fluency and use of language. Sufficient abilities, although with some limitations, of concepts reinterpretation and connection in disciplinary contexts, showing some evidence for autonomously undertaking further studies or professional activity. MARK below 18 LEARNING OUTCOMES ACHIEVEMENT Learning outcomes have been not been met. The student demonstrates most or all of the following characteristics KNOWLEDGE AND UNDERSTANDING Insufficient knowledge and understanding of principles, concepts, methods and techniques of the discipline, with several and significant errors or omissions APPLYING KNOWLEDGE AND UNDERSTANDING Inadequate application of theoretical and technical knowledge for tackling and solving problems. Poor or no evidence of autonomy and effectiveness in facing the issues. MAKING JUDGMENTS, COMMUNICATION SKILLS, LEARNING SKILLS Poor or no evidence of logical, analytical and critical abilities for coherent judgments and decisions attempts. Insufficient ability to communicate knowledge, analyses and conclusions, with

	an acceptable level of clearness, fluency and use of language. Poor abilities of concepts reinterpretation and interdisciplinary connection, showing no evidence for autonomously undertaking further studies or professional activity.
EDUCATIONAL OBJECTIVES	Knowledge of the experimental and theoretical basis of modern physics and of some of its technological applications. Be able to apply this knowledge to solve simple problems on quantum mechanics, nuclear physics and radiation-matter interaction, using first principles and conservation laws.
TEACHING METHODS	Lectures. Instructor-assisted resolution of exercises and problems. Classwork, for single students or groups. Teaching tools: blackboard, chalk sticks, blackboard eraser; computer and video projector.
SUGGESTED BIBLIOGRAPHY	Notes and material provided by the instructor. J. Singh, "Quantum Mechanics: Fundamentals and Applications to Technology", freely available from UniPa IPs: https://onlinelibrary.wiley.com/doi/book/10.1002/9783527618194. D.M. Sullivan, "Quantum Mechanics for Electrical Engineers", 2012, Wiley, ISBN 9780470874097, freely available from UniPa IPs: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118169780 D.M. Kim, "Introductory Quantum Mechanics for Applied Nanotechnology", 2015, Wiley, ISBN 9783527412457, freely available from UniPa IPs: https://onlinelibrary.wiley.com/doi/book/10.1002/9783527677191. D.J. Griffiths, "Introduction to Quantum Mechanics", 3rd ed 2018, Cambridge, ISBN 9781107189638. P. Deak, "Essential Quantum Mechanics for Electrical Engineers", 2017 Wiley, ISBN 9783527413553. S. Trachanas, "An Introduction to Quantum Physics", 2018, Wiley, ISBN 9783527412471. F. Ciccacci, “Fondamenti di Fisica atomica e quantistica, II/2017, Edises, ISBN 9788879599788. F. Ciccacci, A. Benfenati, R. Farinaro, "Introduzione alla Fisica dei Quanti. Temi d'esame risolti", 2016, Edises, ISBN 9788879598996. Web sites: http://mathesis.org/ http://www.st-andrews.ac.uk/physics/quvis/index.php http://www.compadre.org/osp/search/browse.cfm?browse=gsss http://www.sc.ehu.es/sbweb/fisica3/cuantica/portada.html http://www.falstad.com/mathphysics.html

SYLLABUS

Hrs	Frontal teaching
4	Experimental basis of modern physics. Spectral lines. Blackbody radiation. Density of states. Planck's radiation law. Photoelectric effect. Compton effect. Particlelike properties of electromagnetic radiation.
4	Experimental basis of the atomic structure of matter. Atomic models. Thomson model. Rutherford experiment. Bohr atomic model. Franck-Hertz experiment.
2	Matter waves. The wave-particle duality. De Broglies's hypothesis. Davisson and Germer experiment. The Heisenberg uncertainty principle.
6	Introduction to quantum mechanics. The Schrödinger equation. Quantum mechanics formalism. Operators. Eigenvalues and eigenvectors. Observables and measurement. Dirac notation. The statistical interpretation of the wave function. Comparison with the classical probability. Stationary states. The free particle. Wave packet time evolution. Potential well and barriers. GaA-AlGaAs quantum well. Tunnel effect. Harmonic oscillator. Quantum mechanics in three dimensions. Spherical harmonics. Angular momentum. Spin. The hydrogen atom. Eigenvalues and eigenfunctions. Applications: excitons.
2	Classical and quantum statistics. Density of states for particles and photons. Boltzmann, Bose-Einstein and Fermi Dirac distributions. Crystal lattice thermodynamics. Einstein and Debye models.
2	Bloch's theorem. Energy bands in solids. Kronig-Penney model. Energy levels calculation.
6	Introduction to the physics of semiconductors. General features and physical parameters. Direct and reciprocal lattice. First Brillouin zone. Electrons and holes. Effective mass. Density of states of carriers in conduction and valence band. Fermi level. Doping of semiconductors. Mass action law. Carrier Transport in Semiconductors. P–N junction: physics and applications. Diodes and applications.
4	Quantum mechanics of the radiation-matter interaction. Two-level model for atoms. Population kinetics. Stimulated absorption and emission. Spontaneous emission. Perturbative and non-perturbative solutions. Fermi golden rule. Rabi frequency. Three-level systems. Population inversion. Radiation amplification. Laser.

Hrs	Practice
4	Atomic models.
8	Quantum mechanics and its applications. Numerical solutions of the Schrödinger's equation. Use of worksheets. Tunnel effect and applications: tunneling through a square potential barrier, Zener diode, Fowler-Nordheim tunneling, Ohmic contacts, Josephson junction, resonant tunneling.
2	Elements of quantum statistics.

Hrs	Practice
4	Semiconductor physics.
3	Radiation-matter interaction.

Hrs	Workshops
3	Experimental basis of modern physics. Electronic modules of a gamma spectrometry measurement setup. Photoelectric peak and Compton continuum of gamma sources.