Testi del Syllabus

Docente	**LANCERI LIVIO**	Matricola:	**004638**

Anno offerta:	**2012/2013**
Insegnamento:	**010MI - COMPLEMENTI DI FISICA**
Corso di studio:	**IN17 - INGEGNERIA DI PROCESSO E DEI MATERIALI**
Anno regolamento:	**2012**
CFU:	**6**
Settore:	**FIS/01**
Tipo attività:	**C - Affine/Integrativa**
Partizione studenti:	**-**
Anno corso:	**1**
Periodo:	**Primo Semestre**
Sede:	**TRIESTE**

Testi in italiano

Tipo testo	*Testo*
Lingua insegnamento	Italiano/Inglese
Contenuti (Dipl.Sup.)	Introduzione elementare alla Meccanica Quantistica e alle proprietà elettriche dei Semiconduttori. Sono possibili varianti al programma per venire incontro ad altri interessi.
Testi di riferimento	I testi [1] (o in alternativa [2],[3]) e [8] contengono buona parte degli argomenti trattati nel corso; gli altri ([4]-[7])possono essere usati per chiarimenti o approfondimenti. Il testo [9] si riferisce ad un esempio di applicazione (celle fotovoltaiche). Il testo [10] è un manualetto schematico (una pagina per argomento), che può essere utile come promemoria a chi si occupa di materiali dal punto di vista applicativo. [1] J.R.Taylor, C.D.Zafiratos, M.A.Dubson, "Modern Physics for Scientists and Engineers" (2nd ed.) [2] J.Bernstein, P.M.Fishbane, S.Gasiorowicz, Modern Physics, Prentice Hall. [3] J.D.Walecka, Introduction to Modern Physics - Theoretical Foundations, World Scientific Publ.Co. [4] D.J.Griffiths, Introduction to Quantum Mechanics, Prentice Hall. [5] S.J.Blundell, K.M.Blundell, Concepts in Thermal Physics (2nd ed.), Oxford University Press. [6] F.Kittel, Introduction to Solid State Physics, Prentice Hall. [7] H.Ibach, H.Luth, Solid State Physics - an Introduction to Materials Science, Springer. [8] D.J.Neamen, Semiconductor Physics and Devices (3rd ed.), McGraw Hill. [9] J.Nelson, The Physics of Solar Cells, Imperial College Press. [10] A.C.Fischer-Cripps, The Materials Companion, Taylor&Francis Group. [11] M.L.Boas, Mathematical Methods for the Physical Sciences, J.Wiley&Sons.
Obiettivi formativi	Acquisizione di alcune nozioni di base sulla cosiddetta Fisica Moderna; esecuzione di semplici calcoli e stime di ordini di grandezza in fisica atomica e dei semiconduttori.

Tipo testo	*Testo*
Prerequisiti	Nozioni di base in fisica classica (meccanica, termodinamica, elettromagnetismo). Calcolo differenziale, variabili complesse.
Metodi didattici	Lezioni con supporto misto (presentazioni power point in inglese e calcoli alla lavagna). Una visita a laboratori di fisica della materia condensata.
Altre informazioni	La documentazione del corso è disponibile sul sito web "moodle": http://moodle.units.it/moodle/course/view.php?id=169
Modalità di verifica dell'apprendimento	Gli esami si svolgeranno normalmente negli appelli regolari, con possibilità di concordare date alternative. L'esame consiste nella sola prova orale. Al posto della prova scritta, durante il corso vengono assegnati esercizi da risolvere autonomamente; questi esercizi sono materia d'esame, come specificato nel seguito. Di norma la prova orale, della durata di circa tre quarti d'ora, include la discussione di: 1) soluzione di uno degli esercizi assegnati durante il corso; 2) un argomento a scelta del candidato; 3) un argomento a scelta della commissione. Nella prova orale viene verificata anche la familiarità con le unità di misura, gli ordini di grandezza, e la valutazione numerica delle grandezze fisiche rilevanti.
Programma esteso	0. Introduction: Particles and waves, crisis of classical physics 0.1 Classical particles, mechanics. 0.2 Waves: wave equation and solutions 0.3 Electromagnetic waves as particles (“photons”): photoelectric and Compton effects, black-body radiation. 0.4 Particles as “matter waves”: DeBroglie wavelength, electron diffraction by crystals, two-slits diffraction of electrons. Part I: Introduction to Quantum Mechanics I.1 Wave mechanics postulates, the Schrödinger equation and its interpretation I.2 The physical meaning of eigenfunctions and eigenvalues; observables and expectation values I.3 Free particles, separable solutions: plane waves, wave number, phase velocity I.4 Free wave packets, group velocity, uncertainty relations I.5 Particle (electron) bound in an infinite 1-d potential well I.6 Particles: probability density and flux; charge density and current density I.7 Potential energy step: transmission and reflection coefficients I.8 Potential wells and barriers I.9 Hydrogen atom, angular momentum, spin (short introduction); I.10 Many-particle systems: bosons and fermions, Pauli exclusion principle, the Mendeleev table of elements (short introduction). Part II : Introduction to Solid State Physics II.1 Periodic potentials: Bloch theorem II.2 Kronig-Penney model for an electron in a periodic 1-D potential II.3 Allowed and forbidden energy bands, Bragg reflections and Bloch oscillations II.4 Semi-classical equation of motion for electrons (Bloch wave packets) in crystals II.5 Effective mass of electrons II.6 Contributions from electrons in a band to the electrical current in an external electric field II.6 The “hole” concept; properties: wavevector, energy, velocity, effective mass, equation of motion

Tipo testo	*Testo*
	II.7 Insulators, conductors, semiconductors Part III: Introduction to the Physics of Semiconductors III.1 Pure and Doped semiconductors, in thermal equilibrium III.2 Semiconductor materials: resistivity and conductivity III.3 Crystal structure of solids, crystal lattice for Si, Ge, GaAs, Miller indices III.4 Models for charge carriers: electrons and holes (“bond” and “band” models) III.5 Pure (intrinsic) semiconductors at equilibrium: density of available states for electrons, valence and conduction bands; “filling” probability: Fermi-Dirac probability distribution function; concentrations of charge carriers (electrons and holes); Fermi level. III.6 Doped (extrinsic) semiconductors at equilibrium, mass action law; Fermi level as a function of temperature and doping concentrations III.7 Transport phenomena: drift and diffusion, generation and recombination III.8 Introduction to drift and diffusion of charge carriers, current density, Ohm's law. III.9 Electrons in a real crystal: scattering on phonons and defects III.10 Boltzmann transport equation and the relaxation time approximation III.11 Electrical conductivity in metals and in semiconductors III.12 Continuity equations for the transport of charge carriers: drift, diffusion, generation, recombination III.13 Einstein relations between drift and diffusion coefficients; “band-bending” and “built-in” electrical fields for non-uniform doping of semiconductors III.14 Non-equilibrium: “excess” carriers injection; quasi-Fermi levels III.15 Generation and recombination processes in semiconductors; Shockley-Read-Hall model for recombination III.16 Examples of solutions of the continuity equations: (a) Steady-state injection from one side: diffusion length Lp; (b) Minority carriers recombination at the surface; (c) The Haynes-Shockley experimental determination of drift, diffusion and recombination properties (additional topics: drift and diffusion coefficients for ambipolar transport, introduction to applications in solid-state electronic devices)

Testi in inglese

Tipo testo	*Testo*
Lingua insegnamento	Italian/English
Contenuti (Dipl.Sup.)	An introduction to some aspects of Quantum Mechanics and to the Physics of Semiconductors, related mainly to the electrical properties of solid-state electronic devices.
Testi di riferimento	In textbooks [1] (or alternatively [2],[3]) and [8] most of the contents can be found; the other textbooks ([4]-[7]) may be used for further reading. Textbook [9] deals with an example of application (solar cells). Textbook [10] may be useful as a quick reference for materials engineers. [1] J.R.Taylor, C.D.Zafiratos, M.A.Dubson, "Modern Physics for Scientists and Engineers" (2nd ed.) [2] J.Bernstein, P.M.Fishbane, S.Gasiorowicz, Modern Physics, Prentice Hall. [3] J.D.Walecka, Introduction to Modern Physics - Theoretical Foundations, World Scientific Publ.Co. [4] D.J.Griffiths, Introduction to Quantum Mechanics, Prentice Hall. [5] S.J.Blundell, K.M.Blundell, Concepts in Thermal Physics (2nd ed.), Oxford University Press. [6] F.Kittel, Introduction to Solid State Physics, Prentice Hall. [7] H.Ibach, H.Luth, Solid State Physics - an Introduction to Materials Science, Springer. [8] D.J.Neamen, Semiconductor Physics and Devices (3rd ed.), McGraw Hill. [9] J.Nelson, The Physics of Solar Cells, Imperial College Press. [10] A.C.Fischer-Cripps, The Materials Companion, Taylor&Francis Group. [11] M.L.Boas, Mathematical Methods for the Physical Sciences, J.Wiley&Sons.
Obiettivi formativi	Acquisition of some basic notions in Modern Physics; simple computations and order of magnitude estimates in atomic and semiconductor physics.

Tipo testo	*Testo*
Prerequisiti	Basic notions in classical physics (mechanics, thermodynamics, electromagnetism). Basic calculus, complex numbers.
Metodi didattici	Lectures based on power point slides (in English) and on discussions and computations at the blackboard. One visit to laboratories on solid state physics.
Altre informazioni	The documentation is available on the "moodle" web site: http://moodle.units.it/moodle/course/view.php?id=169
Modalità di verifica dell'apprendimento	Exams take place according to the official time table, with the possibility of agreeing on alternative additional dates. The examination consists in an oral discussion (no separate written test). The assignments of exercises during the course are part of the oral examination, as explained below. The examination typically takes about three quarters of an hour, and includes: 1) the solution of one of the numerical exercises given as assignments; 2) a subject chosen by the candidate; 3) a subject chosen by the examiners. Good working knowledge of units, orders of magnitude, and numerical evaluation of the relevant physical quantities is required.
Programma esteso	0. Introduction: Particles and waves, crisis of classical physics 0.1 Classical particles, mechanics. 0.2 Waves: wave equation and solutions 0.3 Electromagnetic waves as particles (“photons”): photoelectric and Compton effects, black-body radiation. 0.4 Particles as “matter waves”: DeBroglie wavelength, electron diffraction by crystals, two-slits diffraction of electrons. Part I: Introduction to Quantum Mechanics I.1 Wave mechanics postulates, the Schrödinger equation and its interpretation I.2 The physical meaning of eigenfunctions and eigenvalues; observables and expectation values I.3 Free particles, separable solutions: plane waves, wave number, phase velocity I.4 Free wave packets, group velocity, uncertainty relations I.5 Particle (electron) bound in an infinite 1-d potential well I.6 Particles: probability density and flux; charge density and current density I.7 Potential energy step: transmission and reflection coefficients I.8 Potential wells and barriers I.9 Hydrogen atom, angular momentum, spin (short introduction); I.10 Many-particle systems: bosons and fermions, Pauli exclusion principle, the Mendeleev table of elements (short introduction). Part II : Introduction to Solid State Physics II.1 Periodic potentials: Bloch theorem II.2 Kronig-Penney model for an electron in a periodic 1-D potential II.3 Allowed and forbidden energy bands, Bragg reflections and Bloch oscillations II.4 Semi-classical equation of motion for electrons (Bloch wave packets) in crystals II.5 Effective mass of electrons II.6 Contributions from electrons in a band to the electrical current in an external electric field II.6 The “hole” concept; properties: wavevector, energy, velocity, effective mass, equation of motion II.7 Insulators, conductors, semiconductors

Tipo testo	*Testo*
	Part III: Introduction to the Physics of Semiconductors III.1 Pure and Doped semiconductors, in thermal equilibrium III.2 Semiconductor materials: resistivity and conductivity III.3 Crystal structure of solids, crystal lattice for Si, Ge, GaAs, Miller indices III.4 Models for charge carriers: electrons and holes (“bond” and “band” models) III.5 Pure (intrinsic) semiconductors at equilibrium: density of available states for electrons, valence and conduction bands; “filling” probability: Fermi-Dirac probability distribution function; concentrations of charge carriers (electrons and holes); Fermi level. III.6 Doped (extrinsic) semiconductors at equilibrium, mass action law; Fermi level as a function of temperature and doping concentrations III.7 Transport phenomena: drift and diffusion, generation and recombination III.8 Introduction to drift and diffusion of charge carriers, current density, Ohm's law. III.9 Electrons in a real crystal: scattering on phonons and defects III.10 Boltzmann transport equation and the relaxation time approximation III.11 Electrical conductivity in metals and in semiconductors III.12 Continuity equations for the transport of charge carriers: drift, diffusion, generation, recombination III.13 Einstein relations between drift and diffusion coefficients; “band-bending” and “built-in” electrical fields for non-uniform doping of semiconductors III.14 Non-equilibrium: “excess” carriers injection; quasi-Fermi levels III.15 Generation and recombination processes in semiconductors; Shockley-Read-Hall model for recombination III.16 Examples of solutions of the continuity equations: (a) Steady-state injection from one side: diffusion length Lp; (b) Minority carriers recombination at the surface; (c) The Haynes-Shockley experimental determination of drift, diffusion and recombination properties (additional topics: drift and diffusion coefficients for ambipolar transport, introduction to applications in solid-state electronic devices)