Bachelor degree = First-cycle degree
Master degree = Second-cycle degree

FOR COURSES BASED ON A SEMESTER ORGANIZATION
First semester: October 1st, 2013 to January 25th, 2014
Second semester: March 3rd, 2014 to June 14th, 2014

FOR COURSES BASED ON A TRIMESTER ORGANIZATION
First trimester: October 1st, 2013 to December 7th, 2013
Third trimester: April 7th, 2014 to June 21th, 2014
MASTER DEGREES OF THE SCHOOL OF SCIENCE WITH ALL THE COURSES IN ENGLISH

1. ASTROMUNDUS
   www.astro.unipd.it/astromundus
2. ALGANT
   (Algebra, Geometry And Number Theory)
   http://lauree.math.unipd.it/algant/node/4

MASTER DEGREES WITH A PROGRAM OF COOPERATION WITH OTHER EUROPEAN UNIVERSITIES FOR COMMON DEGREES

An agreement between the University of Padova and the French Universities Paris Diderot-Paris 7 and Paris Descartes. Has been established since the academic year 2010-11 for the release of a common degree between the Master Degree in Molecular Biology and the Master de Sciences Santé et Application. This project requires the mobility of students (up to 6 per year) within the ERASMUS program. More information is available on http://biologia-molecolare.biologia.unipd.it/organizzazione-ccs/socrates-erasmus

OTHER COURSES IN MASTER DEGREES

Astronomy
Evolutionary biology
Marine Biology
Molecular Biology
Sanitary Biology
Industrial Biotechnology
Chemistry
Industrial Chemistry
Physics
Geology and technical Geology
Computer Science
Mathematics
Material Science
Natural Science
Statistical Science

Academic year 2013 > 2014
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ASTRONOMICAL SPECTROSCOPY

Master degree in Astronomy
Language: English
Teaching period: Second semester
Lecturer: Piero Rafanelli
Credits: 6 ECTS
Examination: oral

The course is aimed at providing the student with a basic knowledge of the physics of plasma with particular attention to the astrophysical plasmas.

Content:
Definition of plasma – Plasmas in astrophysics – Observational data – Different theoretical approaches.
Recalls of dynamics of fluids – Magnetohydrodynamics (MHD).
Waves in plasma fluids – Non linear steepening and shocks – Instabilities.
Collisions – Collisionless plasmas
Cosmic Rays – Fermi acceleration – Shock acceleration
Astrophysical dynamos
Magnetic reconnection
MHD flows in compact astrophysical objects

HIGH ENERGY ASTROPHYSICS

Master degree in Astronomy
Language: English
Teaching period: Second semester
Lecturer: Piero Benvenuti
Credits: 6 ECTS
Examination: oral

 Radiation in the interstellar gas: definition of radiative terms; transfer equation; local thermodynamic equilibrium; equivalent thermodynamic equilibrium. Emission and absorption lines in the interstellar environment: emission and absorption coefficients; statistic equilibrium; collisional processes and kinetic temperature; excitation in interstellar conditions; forbidden lines; recombination lines; intensity of lines as a function of density and temperature.
Continuum emission and absorption processes: free-free transitions; intensity of the thermal radio continuum; bound-free and free-bound transitions; synchrotron radiation.
Ionization: ionization equilibrium; ionization of hydrogen; HII regions; ionization of helium; dust extinction; HI regions; ionization of the heaviest elements. Formation and dissociation of interstellar molecules: molecular hydrogen; CO, OH, H2O in diffuse nebulae; molecules in dense nebulae. Thermal equilibrium and kinetic temperature of gas: Equation of thermal equilibrium; heating and cooling processes of gas; thermal equilibrium of HII regions; thermal state of HI regions.
CELESTIAL MECHANICS

Master degree in Astronomy
Language: English
Teaching period: Second semester
Lecturer: Stefano Casotto
Credits: 6 ECTS
Examination: oral

1. The equations of motion of a system of N bodies - Symmetries and first integrals - Reference frames
2. The Two-Body Problem - The conic section solutions and their representations - Regularization and formulation in universal variables
3. Computation of an ephemeris
5. Relative Keplerian motion - Rendez-vous - Orbital maneuvers
6. Lambert’s theorem - Lambert targeting
7. The Three-Body Problem - Homographic solutions
8. The Circular Restricted Three-Body Problem - The Jacobi integral - Zero velocity surfaces - Periodic orbits

STEellar POPULATIONS

Master degree in Astronomy
Language: English
Teaching period: Second semester
Lecturer: Prof. Gianpaolo Piotto
Credits: 6 ECTS
Examination: oral

The color magnitude diagrams: transformations luminosity-magnitude and temperature-color index. Effects of the interstellar reddening on the color-magnitude diagrams.
The concept of stellar populations: historical background.
Globular Clusters stellar populations
The helium content of the population II stars.
The Galactic model by Eggen, Lynden-Bell and Sandage.
The galactic halo model from Searle and Zinn.
The interstellar medium near to the Sun and the local bubble.
The population I and the galactic disk. Open clusters and field population.
Dwarf Galaxies.
The mass function.
Integrated properties of the stellar populations.
Star formation History in galaxies
Basic principles of the chemical evolution of the stellar populations.
The supernovae: classification, evolution, progenitors.
The use of the supernovae as indicator distances.
1. The Large Scale Structure of the Universe.  
Local properties.  
General and structural properties of the universe. Large scale distribution of galaxies.  
Angular and spatial correlation functions.  
Higher order correlations. Limber relation.  
Power-spectrum of the cosmic structures.  
Relationship of the power-spectrum and $\xi(r)$.  
Observational data on the large scale structure. The initial power-spectrum of the perturbations.  
3D mapping of galaxies, clusters, AGNs.  
Counts-in-cells. Outline of fractal and topological analyses of the universe.

2. The Homogeneous and Isotropic Universe.  
Hubble law. The Cosmological Principle.  
Generalized dynamical equations. The cosmological constant. Observational evidences

3. Deviations from homogeneity and isotropy.  

4. Perturbations in an expanding universe.  
Constraints on the cosmological parameters from the large scale motions.

5. Brief thermal history of the Universe  
Cosmic entropy per baryon. Primordial nucleo-synthesis.

6. The Cosmic Microwave Background  
Discovery of the CMB. Observations from ground and from space. COBE & WMAP. Origin of the CMB.  
Spatial properties, isotropy of the CMB.  
Statistical description of the angular structure. Origin of the CMB angular fluctuations.  
Physical processes in operation on the large scales. Fluctuations on intermediate angular scales. Contributions of sources to the anisotropies on small scales.  
Constraints of CMB observations on the cosmological parameters.  
The CMB spectrum. Spectral distortions.  
The Sunyaev-Zeldovich effect. Observational limits on the spectral distortions and their implications.

7. The Primordial Universe, Big Bang, phase transitions, cosmological inflation.  
The problem of the cosmological horizons. Propagation of the information and visibility of the universe.  
Big Bang singularity. Planck time.  
Overview of the standard model of elementary particles. Fundamental interactions.  
8. The Post-Recombination Universe
Cosmological evolution of galaxies and active
galactic nuclei.
Evolutionary history of star formation and
production of heavy elements. Contributions to
the background radiations.
Intergalactic diffuse gas. Absorption-lines
in quasar spectra, Lyman-alpha clouds. The
missing baryon problem.

1. Introduction and overview.
Observational constraints, the H-R diagram,
mass-luminosity and mass-radius relations, stellar
populations and abundances.

2. Hydrostatics, energetics and timescales.
Derivation of three of the structure equations
(mass, momentum and energy conservation).
Hydrostatic and thermal equilibrium. Derivation
of the virial theorem and its consequences for
stellar evolution. Derivation of the characteristic
timescales of stellar evolution.

Local Thermodynamical equilibrium. General
derivation of n, U, P from statistical mechanics.
Limiting cases: ideal gas, degeneracy. Mixture of
gas and radiation. Adiabatic processes. Ionization
(Saha equation, consequences for thermodynamic
properties).

The 4th equation of stellar structure: the energy
transport equation.
Diffusion approximation for radiation transport.
The radiative temperature gradient. Opacity.
Eddington luminosity. Convection: Derivation
of stability criteria (Schwarzschild, Ledoux.
Convective energy transport: order-of-magnitude
derivation. Mixing-length theory.

5. Nuclear reactions.
Nuclear energy generation (binding energy).
Derivation of thermonuclear reaction rates
(cross sections, tunnel effect, Gamow peak).
Temperature dependence of reaction rates.
Nuclear burning cycles: H-burning by pp-chain
and CNO-cycle. He burning by 3-alpha and
alpha+C reactions. Advanced burning reactions.

Overview, time/space derivatives, limiting cases.
Boundary conditions and their effect on stellar structure. How to obtain solutions.

7. Simple stellar models.
   Polytrophic models. Homology relations: principles, derivations, application to contraction and the main sequence. Stability of stars: derivation of simplified criteria for dynamical and secular stability.

8. Schematic evolution from the virial theorem (VT).
   Evolution of the stellar center combining the VT and the EoS: evolution tracks in terms of (P,rho) and (T,rho). Evolution towards degeneracy or not. The Chandrasekhar mass, low-mass vs massive stars. Critical ignition masses, brown dwarfs, nuclear burning cycles.

9. Detailed evolution: towards and on the main sequence.
   Simple derivation of Hayashi line, pre-MS evolution tracks properties of the ZAMS: M-L and M-R relations, occurrence of convection zones evolution across the MS band: structural changes, low-mass vs high-mass, effects of overshooting.

10. Post-MS evolution.

11. Late evolution of low- and intermediate-mass stars.
    The Asymptotic Giant Branch: thermal pulses, 2nd/3rd dredge-up, mass loss, nucleo-synthesis. White dwarfs: structure, non-ideal effects, derivation of simple cooling theory.

12. Pre-SN evolution of massive stars.
    Importance of mass loss across the HRD (O stars, RSG, LBV and WR stars). Modern evolution tracks. Advanced evolution of the core: nuclear burning cycles and neutrino losses, acceleration of core evolution. Pre-SN structure.

13. Explosions and remnants of massive stars.
    Evolution of the core towards collapse: Fe-disintegration, electron captures, role of neutrinos supernovae. Observed properties and relation to massive star evolution. Limiting masses for neutron star and black hole formation, dependence on mass loss and metallicity.

ASTROPHYSICS OF GALAXIES

Bachelor degree in Astrophysics
Language: English
Teaching period: Second Semester
Lecturer: Giuseppe Galletta
Credits: 6 ECTS
Examination: oral

Inside the luminosity distribution of galaxies. Surface brightness laws in 2-D and 3-D. Freeman, De Vaucouleurs and Sersic laws. Theoretical relations between main luminosity parameters (effective radius, scale length, slope, effective and total magnitudes). Deduction of the main parameters from the observations. Fit of a composite luminosity profiles with simple software (IRAF, Mathematica routines). Galaxies in 3-D.

The tridimensional shape of galaxies. Statistical methods. Inclination of a galaxy: principal planes and methods to find inclination and line of the nodes. Polar ring and other reference planes. Twisting of the isophotes. 3D distribution: Exponential and Young density profiles.

Observing at other wavelengths. HI and CO lines. Observing techniques in our and other galaxies. Forbidden lines, roto-vibrational bands. The molecular universe: detection of complex molecules. The role of Sub-millimetric telescopes and ALMA. Hot stars and the GALEX view of galaxies. Mining in astronomical archives. Web astronomy. Motions in the milky Way.

Velocity ellipsoid near the Sun. Methods and applications: compute the orbit for a nearby star in the galactic potential. Tracers of spiral structure. Oort formulae.

The global dynamics of a galaxy: Stars and gas. Asymmetric drift, anisotropy in the velocity dispersion ellipsoids. Observable effects of the anisotropy and of the influence of the velocity dispersion on galaxy spectra. Non isotropic local and global dynamics. Bars, rings, polar and inclined disks. Theories

GALAXY DYNAMICS

Bachelor degree in Astrophysics
Language: English
Teaching period: Second Semester
Lecturer: Luigi Secco
Credits: 6 ECTS
Examination: oral

The cosmological framework: brief history of the shift sequence for Life site and the birth of modern cosmology. Cosmological Principles; Einstein’s equations (by analogy), Robertson-Walker metric. Einstein’s and de Sitter solutions. Crucial phases of the cosmological evolution; formation of micro-structures in order to allow the macro ones and the macro-micro interplay; Jeans instability and role of dark matter; spherical collapse of a density perturbation. Structures on galaxy mass scales in the CDM scenario and their phases before virialization. The thermodynamic perspective: entropy and information; violent relaxation mechanism in phase-space; statistic of Lynden-Bell, Shu, Kull-Treumann & Boeringer, Nakamura; Landau-damping and virialization. Stress tensor and anisotropies of peculiar velocities in the dynamics of stellar systems. The tensor virial theorem for one and two-component system and its proof from Euler equation and from Boltzmann equation. Application to $v_{rot}/\sigma$ diagram of elliptical galaxies. Dark virialized haloes: the general Zhao-density profiles. The Fundamental Plane of galaxies and related problems. The cosmic metaplane.
ETHOLOGY

Master degree in Evolutionistic Biology
Language: English
Teaching period: Second semester
Lecturer: Prof. Andrea Pilastro
Credits: 6 ECTS
Examination: written

This course introduces the students to the scientific study of the behavior of animals. Providing a theoretical framework, illustrated with numerous examples, all aspects of animal behavior are discussed. Students will be encouraged to think about the evolutionary origin and adaptive significance of behavior. Main topics will regard the link between animal behavior ecology and evolution, the development and control of behavior: genes environment and neural mechanisms, the evolution of animal signals, adaptive responses to predators, foraging behavior and optimality models, reproductive behavior: male and female tactics, mating systems, parental care, sperm competition and sexual selection, sexual conflict, social behavior, kin selection.

EVOLUTION AND CONSERVATION

Master degree in Evolutionistic Biology
Language: English
Teaching period: First semester
Lecturer: Prof. Andrea Pilastro
Credits: 6 ECTS
Examination: written

The course will focus on genetic and evolutionary applications to the problems of conservation, while reflecting the diversity of concerns that are relevant to conservation biology. Particular emphasis will be put on themes like measures of phylogenetic diversity and uniqueness, population genetic structure of natural and managed populations including the identification of ‘evolutionary significant units’ and ‘management units’ for conservation, assessment of levels of genetic variation within species and populations, assessments of the effect of sexual selection mate choice and reproductive strategy on population conservation, forensic applications, methods for maximizing genetic diversity during captive breeding programs and re-introduction schemes, effect of anthropogenic factors on evolutionary adaptation to local changes in the environment.
Molecular Ecology and Demography of Marine Organisms

Master degree in Marine Biology
Language: English
Teaching period: First semester
Lecturer: Prof. Lorenzo Zane
Credits: 7 ECTS
Examination: written

The course will emphasize the potential offered by molecular genetic approaches in the study of populations of marine organisms. The topics covered by the course will provide a link between marine population ecology and molecular ecology. The program will first highlight the traits of marine organisms relevant for population dynamics and for the determination of genetic variability and differentiation, and then will focus on the use of molecular markers for identification of individuals, stock, populations and species. Molecular markers will be presented with a practical approach, including class and laboratory activity and literature analysis, with the aim of evidence the experimental approach currently used in molecular ecological studies, the kind of data produced and the available strategies for data analysis.

Biodiversity and Behavior

Master degree in Marine Biology
Language: English
Teaching period: Second semester
Lecturer: tbd
Credits: 8 ECTS
Examination: written

The course will present the variability in morphological, physiological, and behavioral traits, in relation to environmental characteristics, displayed by marine organisms. Applying an evolutionary approach, the main adaptations to different marine habitats (i.e. pelagic, benthic, abyssal, intertidal) will be covered. The theories of the behavioral ecology (i.e. sexual selection, optimality models) will be presented in order to understand the variability in behavioral traits. Behaviors related to reproduction, parental care, mimetism, gregariousness and foraging will be covered, with exampled from different marine taxa.

Exercise in class room: Journal club, virtual research program. 
Laboratory exercise: purification and biochemical characterization of a membrane protein (preparation of thylakoids, membrane solubilization, alkaline extraction, treatment with protease, SDS-PAGE, Western blot).

Learning of theoretical and practical skills in the field of molecular embryology with emphasis on signaling pathways involved in induction, patterning, determination and differentiation of animals.
- Molecular mechanisms of cleavage, gastrulation and morphogenesis in animal models. Genetic dissection of early development.
- Molecular gradients controlling axis formation in vertebrates and Drosophila.
- Paradigms of molecular developmental genetics.
- Acquisition of skills in the presentation of scientific results; performance of practical molecular embryology experiences and their written reports. Principles of digital imaging applied to embryology.
Examination: the exam will be a combination of different tests such as: 1) slide presentation of an article (Journal Club) graded for clarity, completeness of presentation and ability to raise a discussion 2) report of practical laboratory activity and imaging skills 3) Answer an open question on one issue of the course.
The course covers several aspects concerning karyotype plasticity and evolution, and the evolution of the molecular mechanisms involved in genome regulation and stability. 2 ECTS: Chromosome organization: banding, interphase domains, isochores; the concept of synteny; synteny conservation and models of human disease; karyotype variations in evolution; evolutionary breakpoints; evolution of centromeric sequences; neocentromeres in evolution and disease.

2 ECTS: Evolution of sex-chromosome divergence; the molecular mechanisms for dosage compensation of sex-chromosome associated genes: the classical paradigm and new insights; evolution and significance of genomic imprinting. 1 ECTS: Gene dosage imbalance and dosage compensation mechanisms; copy number variation and disease. 1 ECTS: critical reading.
**GENETIC DISEASES AND MODEL SYSTEMS**

Master degree in Molecular Biology  
Language: English  
Teaching period: First semester  
Lecturer: Mauro Agostino Zordan  
Credits: 4 ECTS  
Examination: written  

The course is organized as a series of one-hour seminars on topics dealing mainly with genetic diseases and the use of model organisms in genetic disease research. Topics typically touch upon molecular aspects of select genetic diseases and on the application of models such as in vitro mammalian cells, yeast, Drosophila, zebrafish, and mouse to study the pathogenetic mechanisms of specific genetic defects. Generally, the course activity consists in 12 seminars, which are held during an intensive one-week period. The final exam will be written and consists in reading a scientific paper dealing with the subject exposed in one of the seminars and, on the basis of the paper’s content, writing an abstract, which for the occasion, will have been concealed from the original paper.

**HUMAN PHYSIOLOGY**

Master degree in Medical Biology  
Language: English  
Teaching period: First semester  
Lecturer: Luigi Bubacco  
Credits: 9 ECTS  
Examination: written  

This course is designed to provide students with an understanding of the function and regulation of the human body and physiological integration of the organ systems to maintain homeostasis. Course content will include neural and hormonal homeostatic control mechanisms, as well as study of the musculoskeletal, circulatory, respiratory, digestive, urinary, reproductive, and endocrine organ systems. Principles of the physiology of special senses, vision, hearing, taste, and smell will be emphasized throughout in the semester in dedicated critical reading assignments. Prerequisite courses: General physiology or similar physiology courses. It is assumed that all students have knowledge of biochemistry, cell biology, molecular cell mechanisms and basic concepts of physiological control mechanisms.
The course consists in 56 hours of lectures that will describe the major causes of diseases, including physical agents, chemicals, drugs, toxins, viruses, bacteria and fungi. The mechanism of pathogenesis of the diseases they cause in humans will be discussed as well as diseases due to alteration of the immune responses. The course then will treat briefly the mechanism of defense and the reaction of regeneration and repair. The major diseases of blood circulation from heart failure and ischemia to atherosclerosis will be then described. This will be followed by the major human neuro-degeneration diseases. The last part of the course will deal with the molecular, cellular, histological, genetics, clinical pathogenesis of cancers. The course is integrated by 32 hours of laboratory with experiences on immunological reactions and histopathology of tissue degeneration, atherosclerosis, inflammation and cancers. Examination: it will be performed with a written test based on three major questions and integrated by an oral part which builds up on the written part.
The course will introduce the basic concepts of environmental toxicology, will illustrate chemical reactions mediating the action of pollutants in the various environmental compartments, variety of toxic agents and mechanisms underlying the effects induced at different levels of biological organization. Students should acquire critical knowledge on the • principles of toxicology, • natural and man-made toxins, • mechanisms of toxicity, with special attention to heritable changes and genomic instability, • measures and test systems for toxicant identification and risk assessment for both humans and ecosystems.

Following an inter-disciplinary approach, the students will acquire effective document search and critical evaluation ability on selected problems caused by toxic agents.

IMMUNOLOGIC BIOTECHNOLOGY

Master degree in Industrial Biotechnology
Language: English
Teaching period: First semester
Lecturer: Emanuele Papini / Regina Tavano
Credits: 8 ECTS
Examination: oral

Aim: understanding vaccinology in its basic medical terms, having a view on the microbiological, molecular biology and chemical approach to design vaccine nowadays. To understand adjuvancy: empirically and rational design and its connections with nanomedicine. Content of the course: Classic Vaccinology; Main problems in the development of a vaccine; production of recombinant vaccines; Microbial, animal and vegetal models for vaccine production - Reverse Vaccinology: genome based antigen individuation (in silico). Production, quality control; Main vaccines in the paediatric prevention in Italy; Adjuvants - Mucosal adjuvant- micro-nanosized new generation adjuvants. The use of dendritic cells in therapy: perspectives. Practical part: Evaluation in vitro of adjuvancy in human dendritic cells. Isolation of monocytes from blood, their differentiation into Dendritic Cells (DCs). Stimulation of DCs with various adjuvants and analysis of cell activation by Elisa (TNF) and flow cytometry (CD86, CD11), RT-PCR (TNF gene transcription). Autologous/heterologous T lymphocytes proliferation and characterisation of their immunological competence by FACS in vaccine design.

NANOBIO TECHNOLOGY

Master degree in Industrial Biotechnology
Language: English
Teaching period: First semester
Lecturer: Fabrizio Mancin / Emanuele Papini
Credits: 8 ECTS
Examination: oral


Bioenergy:
Introduction; current energy sources and the necessity of researching renewable fuels.
The production of bioethanol from ligno-cellulosic biomasses; production of biodiesel from oleaginous crops.
The biotechnological challenges for biofuels production: the optimization of conversion of solar into chemical energy.
Algae as biofuels producers. Evaluation of advantages and disadvantages with respect to plants. Algae cultivation and domestication.
Biotechnological approaches for biofuels production in algae. Examples of genetic improvements for biofuels.
Biotechnological approaches for hydrogen production in algae and bacteria.
Examination: Oral, discussion on the subject starting from a recent literature paper.

Chemical kinetics in terms of simple and complex reaction schemes, and current theories. Marcus and nonadiabatic electron-transfer theories. Electrochemical kinetics. The students are then involved in real kinetic experiments. Fundamentals and application of statistical thermodynamics. Electric properties of molecules in connection with the dielectric properties of matter. Molecular interactions, in terms of pair interactions and their expressions as a function of molecular quantities, with application to ionic crystals and fluids. Interaction of molecules with electromagnetic fields.
THEORETICAL CHEMISTRY

Master degree in Chemistry
Language: English
Teaching period: Second semester
Lecturer: Antonino Polimeno
Credits: 6 ECTS
Examination: oral + written (optional)

The course introduces the basic theoretical skills for the comprehension of molecular processes in condensed phases, and for the interpretation of spectroscopic measurements. Methods will be exemplified in some cases using computer simulations. Classic (non-relativistic) mechanics methods for chemical systems, including molecular dynamics methods for the study of roto-translational motion in condensed phases. Quantum non-relativistic methods in chemistry, including angular momenta, group theory, Hartree-Fock, DFT, multiconfigurational approaches to electronic structures in molecules, linear response theory, stochastic approaches to molecular motions. Examination: oral and (optional) written paper on a chosen subject

CHEMISTRY OF ORGANIC MATERIALS

Master degree in Chemistry
Language: English
Teaching period: Second semester
Lecturer: Enzo Menna
Credits: 6 ECTS
Examination: oral

The course program covers main application fields for advanced organic materials. Each application will be discussed with regard to: theoretical bases required to understand how the material works, different chemical classes, different kind of structures, synthesis and characterization, structure-property relationships, device fabrication techniques, examples of application. The following topics will be considered: Fullerenes, nanotubes and other carbon nanostructures, Organic photovoltaic devices, Organic electroluminescent materials (OLED), Self assembled layers of organic molecules, Molecules for non-linear optics, Biomimetic materials, Structural organic materials (main classes of plastic and engineering polymers, their application, synthesis and properties).
Electrochemistry is described from a detailed description of the equilibrium and transport properties of the phases forming the electrochemical systems. Electrochemical kinetics in terms of electron transfer, mass transport, and associated chemical reactions as the rate determining steps. Main electrochemical methods, such as chronoamperometry, cyclic voltammetry and rotating-disk electrode voltammetry, with emphasis on highlighting the above principles and the type of electrode response to the possible rate-determining regimes. Effect of electrode size. Main scanning electrochemical methods, where tiny conductive probes are used to study and/or modify surfaces.

Study aims: identification of organic molecules through the analysis of NMR and mass spectra. Contents: Pulsed NMR (instrumentation, chemical shift, relaxation, scalar coupling, effects of molecular symmetry, decoupling). Dynamic NMR. C-13 NMR. Nuclear Overhauser effect. Introduction to correlation spectroscopy. Mass spectrometry. Instrumentation: ion sources and ionization processes (EI, CI, ESI, APCI, APPI, MALDI); mass analyzers (quadrupole, linear and tridimensional ion trap, time-of-flight analyzer, magnetic and electromagnetic analyzers, hybrid instruments); detectors. Tandem mass spectrometry (MSn), collision induced dissociation (CID). Hyphenated methods (GC/MS, LC/MSn). Applications.
BIOPOLYMERS

Master degree in Industrial Chemistry
Language: English
Teaching period: First semester
Lecturer: Stefano Mammi
Credits: 6 ECTS
Examination: oral

The course describes in general terms the study of structural properties of biological macromolecules, such as polypeptides and proteins, polynucleotides, and polysaccharides. The course is divided into three parts: in the first one, the structural properties of natural and synthetic biopolymers are described and discussed while the second describes some industrial applications of artificial and natural biopolymers and biocompatible and/or biodegradable polymers; finally, the main methods for the study of conformations, interactions and conformational transitions of biopolymers are considered in the third part.

PHYSICAL METHODS IN ORGANIC CHEMISTRY

Master degree in Industrial Chemistry
Language: English
Teaching period: First semester
Lecturer: Alessandro Bagno / Cristina Paradisi
Credits: 6 ECTS
Examination: written

Study aims: identification of organic molecules through the analysis of NMR and mass spectra. Contents: Pulsed NMR (instrumentation, chemical shift, relaxation, scalar coupling, effects of molecular symmetry, decoupling). Dynamic NMR. C-13 NMR. Nuclear Overhauser effect. Introduction to correlation spectroscopy. Mass spectrometry. Instrumentation: ion sources and ionization processes (EI, CI, ESI, APCI, APPI, MALDI); mass analyzers (quadrupole, linear and tridimensional ion trap, time-of-flight analyzer, magnetic and electromagnetic analyzers, hybrid instruments); detectors. Tandem mass spectrometry (MSn), collision induced dissociation (CID). Hyphenated methods (GC/MS, LC/MSn). Applications.
INTRODUCTION TO QUANTUM ELECTRODYNAMICS

Master degree in Physics
Language: English
Teaching period: Second semester
Lecturer: Stefano Rigolin
Credits: 6 ECTS
Examination: oral

The main goal of the course is to offer a basic introduction to relativistic quantum field theory, for graduate students with interest in theoretical and experimental high energy particle physics. Langrangian and Hamiltonian description for classical fields will be shortly reviewed, focusing in particular on the relation between symmetry properties of the action and conservation laws. The quantization for free spin 0, spin 1/2 and spin 1 fields (in the covariant approach) is introduced, through the so called “canonical quantization” procedure. The case of interacting fields is discussed by the introduction of the scattering matrix formalism. With the aid of Feynman graphs the most relevant QED processes at the lowest order are calculated.

THEORY OF FUNDAMENTAL INTERACTIONS

Master degree in Physics
Language: English
Teaching period: Second semester
Lecturer: Andrea Wulzer
Credits: 6 ECTS
Examination: oral

The course aims to provide a first introduction to the Standard Model of Electroweak and Strong interactions, discussing its theoretical foundations and the main experimental confirmations of its validity. An elementary knowledge of relativistic Quantum Field Theory and of the use of Feynman diagrams is required. Topics covered include: non-Abelian gauge theories; spontaneous breaking of global and local symmetries; formulation of the Standard Model theory; effective field theories and the Fermi theory of weak interactions; muon decay and neutral current scattering; physics at the Z pole (LEP); VCKM matrix and CP violation; unbroken symmetries in Quantum Field Theory; the QCD Lagrangian and its symmetries; semileptonic matrix elements and meson decays; the system of neutral Kaons, CP violation and GIM mechanism; asymptotic freedom and parton model; neutrino masses and oscillations; the Standard Model as an effective field theory and the Hierarchy Problem.
Focusing on the metapelitic system, and through extensive practice at the microscopic laboratory, the course will provide deep insight into the main aspects of metamorphic petrology, such as: metamorphic classification; equilibrium assemblages; metamorphic facies; chemographies and other graphical representations; metamorphic reactions and equilibria; role of fluids in metamorphism, fluid inclusions; geothermobarometry and phase equilibria calculations; metamorphism of pelites; contact metamorphism; crustal anatexis; microstructures of anatectic rocks; melt inclusions in migmatites and granulites.

This course examines in depth application aspects of petrography with reference to the following arguments: physical-chemical properties and decay of natural ornamental and dimension stones; traditional ceramic materials; hydraulic and non-hydraulic binders; applications to archaeometry.

1. Introduction to sedimentology (definition of facies and facies association, textural features of sediments, stratal geometries);
2. Processes of sediment transport and deposition (tracial transport by unidirectional and oscillatory currents; mass transport);
3. Post depositional modifications and soft-sediment deformations;
4. Continental depositional environments (alluvial, lacustrine and eolian);
5. Coastal depositional environments (wave-dominated coasts, deltas, tidal flats);
6. Deep marine depositional environments (turbiditic and contouritic systems);
7. Sequence Stratigraphy (base level, systems tracts, key surfaces, incised valleys, non-marine sequence stratigraphy).
STRATIGRAPHY

Master degree in Geology and technical Geology
Language: English
Teaching period: Second semester
Lecturer: Nereo Preto
Credits: 6 ECTS
Examination: written

The aim of this course (or unit) is to make the student familiar with the sedimentary processes, depositional geometries, stratigraphy and diagenesis of carbonate systems. Besides, the student will be introduced to some specific methods of carbonate rock analysis, namely the study of carbonate microfacies and the stable isotope geochemistry (oxygen and carbon) of sedimentary carbonates. Programme: elements of physical oceanography and the inorganic carbon cycle; modes and products of carbonate precipitation in seawater; carbonate factories and carbonate platforms; depositional architecture and stratigraphy of carbonate systems; diagenesis of sedimentary carbonates and dolomitization; microfacies analysis of carbonate rocks; stable isotopic geochemistry of sedimentary carbonates and its application to the reconstruction of diagenetic histories.

BASIN ANALYSIS

Master degree in Geology and technical Geology
Language: English
Teaching period: Second semester
Lecturer: Massimiliano Zattin
Credits: 6 ECTS
Examination: written

The course is intended to cover modern concepts of tectonics and analysis of sedimentary basins through the illustration of geodynamic systems involving basin development. After a first view of classification schemes, basics and mechanics of basins formation will be therefore described in their plate tectonic environment and according to the geodynamic regime: rifts and passive continental margins, orogenic wedges and lithospheric buckling, strike-slip settings. The different topics will be illustrated through many examples from around the world. The course will include a review of key analytical techniques for a quantitative approach with a focus on burial history analysis.
The course will deliver the fundamentals of petroleum geoscience, from the origin and distribution and properties of petroleum to petroleum-bearing rocks. Course topics will be illustrated through case histories and include: the chemistry of petroleum, the organic matter and its maturation in source rocks, petroleum migration, the seal, geology of reservoirs and trap classification. The course will therefore provide the essential tools for understanding the concepts of petroleum system and petroleum play. Case histories will be used to support the concepts and methods, with special emphasis placed upon problems presented by exploration and including some hints about petroleum economics.

Operational program semantics. Denotational program semantics. Static program analysis by abstract interpretation. Dataflow program analysis. Software verification by model checking.
This class offers an overview of issues related to systems and services on wireless networks. Main problems and protocol solutions available for wireless environments are analyzed, including possible alternatives regarding the state-of-the-art in wireless communication. Through the analysis of services that can be offered over wireless technology, the student will become aware of the future possible evolution and utilization of wireless systems.

The course is divided in three main parts. The first part is an extensive introduction on Biology presented as a scientific field centered on Information. The mechanisms that facilitate the transmission and evolution of biological information is be used to introduce some biological issues that require computational approaches. The second part of the course describes the main algorithms used for the alignment of biological sequences, including those designed for “next generation sequencing”. The algorithms used for de novo genomic assembly are also described. Finally, the third part of the course covers several aspects of bioinformatics related to functional genomics, such as the analysis of transcription, gene prediction and annotation, the search of patterns and motifs and the prediction of protein structures. The role of Bioinformatics in individual genomic analysis and personalized medicine is also discussed.

General introduction to group theory: actions of groups, solvable and nilpotent groups, finitely presented groups. A short history of the classification of finite simple groups. Topological groups. Profinite groups (characterizations, profinite completion, countable based profinite groups, arithmetical properties, subgroups of finite index in profinite groups, Galois groups of infinite dimensional extension). Probabilistic methods in group theory.
This is a second course in Modules over arbitrary Rings and in Abelian Categories. A particular emphasis will be on homological algebra and homological dimension. The course consists in studying Additive and Abelian categories - Functor categories - Limits and colimits - Adjoint functors - Chain complexes, homotopy theory - Left and right derived functors: Tor and flatness, Ext and extensions - Homological dimensions.

The aim of the course is to introduce the language of schemes connected with classical algebraic geometry. We will introduce Projective and affine varieties, relation with commutative algebra, Blow ups. Schemes and sheaves. The topological notion translated in this setting: separateness, properness, smoothness. An introductions to some invariants.
The aim of the course is to give an introduction to the Galois theory of homogeneous linear differential equations. This theory goes back to the 19th century and parallels the Galois theory for algebraic field extensions. It studies the (usually non-algebraic) extensions obtained by adding to a function or power series field a full set of solutions of a differential equation. The notions of splitting field of a polynomial, Galois group and solvability by radicals have their counterpart in the notions of Picard-Vessiot extension, differential Galois group and solvability by quadratures. The differential Galois group of a homogeneous differential equation is a linear algebraic group, carrying both the structure of an algebraic variety and a group law given by algebraic functions.

We study the arithmetic of local fields as follows: we study DVR, then completions of rings and fields with respect to a linear topology, then finite extensions of local fields, infinite algebraic extensions of local fields and finally completions of such.
**FUNCTION THEORY**

Master degree in Mathematics  
Language: English  
Teaching period: First semester  
Lecturer: Pierdomenico Lamberti  
Credits: 8 ECTS  
Examination: written + oral


**COMPLEX ANALYSIS**

Master degree in Mathematics,  
Language: English  
Teaching period: Second semester  
Lecturer: Piero Polesello  
Credits: 6 ECTS  
Examination: written


TOPLOGY 2

Master degree in Mathematics
Language: English
Teaching period: First semester
Lecturer: Andrea D’agnolo
Credits: 6 ECTS
Examination: oral

Algebraic Topology is usually approached via the study of the fundamental group and of homology, defined using chain complexes, whereas, here, the accent is put on the language of categories and sheaves, with particular attention to locally constant sheaves and their cohomology. Sheaves were invented by Jean Leray as a tool to deduce global properties from local ones. This tool turned out to be extremely powerful, and applies to many areas of Mathematics, from Algebraic Geometry to Quantum Field Theory. On a topological space, the functor associating to a sheaf the space of its global sections is left exact, but not right exact in general. The derived functors are cohomology groups that encode the obstructions to pass from local to global. The cohomology groups of the constant sheaf are topological (and even homotopical) invariants of the space, and we shall explain how to calculate them in various situations. Lectures will be organized as follows:
Categories and functors, Additive and abelian categories, Abelian sheaves on topological spaces, Cohomology of sheaves

SUPERCONDUCTING MATERIALS

Master degree in Material Science
Language: English
Teaching period: Second semester
Lecturer: Vincenzo Palmieri
Credits: 6 ECTS
Examination: oral

The course will start from the treatment of normal metal conduction both in d.c. regime and in radiofrequency regime and from that will immediately focus on the zero-resistance and on the diamagnetic behavior of superconductors. The two fluid model of a superconductor will be studied in detail and from that we will phenomenologically arrive to the need of Bose condensation and BCS theory. In the end of the course some applications of superconducting materials will be reviewed with special attention to the market of superconducting materials for particle accelerators.
The course covers the main families of devices for the electrochemical conversion and storage of energy, including primary and secondary batteries, fuel cells, photovoltaic cells and redox flow batteries. The fundamentals of the electrochemical processes taking place at the electrodes are discussed, with a detailed analysis of the interplay between the thermodynamics, kinetics and electrochemistry of the various phenomena. The main properties of the electrolytes are also studied, with a particular reference to the conductivity and charge transfer mechanism. The materials science of the functional materials is covered in detail, highlighting the main physicochemical features and applicability of the various systems. The course is completed by the discussion of the main families of: (a) fuel cells, including PEMFCs, PAFCs, MCFCs and SOFCs; (b) redox flow batteries, such as conventional and hybrid systems; and (c) photovoltaic cells.

Interaction of electromagnetic fields with matter will be described for low and high intensity fields, like those of pulsed lasers, and therefore for the description of linear (absorption and refraction) and non linear (from second order to higher orders effects) properties of matter. Simple models and quantum mechanical approaches will be used for obtaining the optical responses of materials and for obtaining the description of phenomena like Sum Frequency Generation, Difference Frequency Generation, for second order effects, or other third order and higher order effects, like Two Photon Absorption, and dynamics of excited state absorptions. Attention will also be given to the properties of nanostructured materials, like plasmonic properties which induce very interesting effects like SERRS (surface enhanced resonance Raman scattering).
ENVIROMENTAL MINERALOGY

Master degree in Natural Science
Language: English
Teaching period: Second semester
Lecturer: Gilberto Artioli
Credits: 6 ECTS
Examination: oral + seminar

Aims: the course will introduce the fundamental concepts of the mineralogy and the petrology of Earth's crust materials, as a base to characterize and interpret natural and anthropogenic processes having environmental implications. The program will encompass several case-studies. Each case will be discussed under the point of view of the analytical and instrumental problems, of the physico-chemical mechanisms, and of the interpretative methodologies of the processes.

Programme:
Natural solid materials: basic concepts of mineralogy and petrology.
Natural processes. Introduction on the distribution of the chemical elements on the Earth's crust, on the geological processes, on the geochemical cycles. Processes and fluid-solid interactions at the mineral surfaces.
Experimental techniques to study materials surfaces.
Case studies:
- Hazardous minerals in nature and in working places: asbestos, free silica. Environmental monitoring, assessment, mineral quantification, disposal.
- Microporous minerals: clays, zeolites. Crystal structure, crystal chemistry, absorption properties, ionic exchange properties, catalysis. Their use in environmental and industrial applications.
- Mineral dust. Origin, characterization. Implications for the palaeoclimatic and environmental reconstructions of the investigations of mineral dust entrapped in polar ice.
The topics will be shown and discussed with the aid of specific scientific literature.

Teaching aids:
- web notes and material (http://www.geoscienze.unipd.it/studenti/artioli/HTC/index.html)
- issues of the journal “Elements” (http://www.elementsmagazine.org/index.htm)
The final examination will include an oral colloquium on the course programme and a student's seminar on a specific topic selected among those discussed during the course and integrated by specific readings.
Objectives
To provide the students with the basic theory and practice for conducting the principal procedures for environmental evaluations
A student who has met the objective of the course will be able:
• To know Environmental Impact Assessment (EIA) and Strategic Impact Assessment (SEA) procedures
• To know the main legislative and regulatory dispositions at national and international levels (UE, UNECE, USA, Italian Legislation and some regional legislation)
• To handle the preparation of the Environmental Impact Statement under EIA procedure and Environmental Report under the SEA procedure
• To deal with the impact on biodiversity under Habitat Directive and the assessment of implications
• To manage tools for environmental assessment
• To manage tools for participation management under environmental evaluation procedures

Program
• The role and need for evaluation
• Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA): regulations, procedures, case studies, European and International comparisons
• Art. 6 of Habitat directive and assessment of implications on Natura 2000 sites: procedures and case studies
• Landscape and Visual Impact Assessment: procedures and case studies
• Social Impact Assessment and interaction with environmental assessment: key case studies
• Ecosystem services approach in environmental assessment
• GIS techniques and Multi Criteria Models for environmental assessments
• Integrated pollution prevention and control (IPPC)
• Accounting methods for environmental good and services: Contingent Evaluation, Cost/Benefits Analysis
• The management of participation inside environmental assessment procedures
• Voluntary tools: Environmental Managements Systems (EMAS and ISO 14.001) and Environmental Certification of Products (EPD and Ecolabel)
PERSONNEL ECONOMICS

Master degree in Statistical Science
Language: English
Teaching period: Second Trimester
Lecturer: Paola Valbonesi
Credits: 8 ECTS
Examination: oral

The course studies the (intrinsic and extrinsic) motivations of employees within the firm and places emphasis on the firms’ practices on compensation and incentives. Drawing upon both on the principal-agent theory and the literature based upon the incomplete contract model, the course investigates how better incentives can improve decision-making: a well designed incentive plan can indeed be an important source of value creation. Understanding basic incentive theory provides you with intuition that is useful in many business exchanges: for example, many of the “relational” issues proper of the employee-firm interaction can be found in the relational governance between firms, or between government and business, in clusters and procurement. Evidence of these extensions will be also discussed in the course. The course is organised in 3 parts. We first approach “A) The agency theory and the theory incentives”; then we present “B) How incentives work within firms”, mainly focussing on moral hazard issues in the principal-agent setting; and, finally, we investigate “C) How incentives work between firms”, investigating - among other topics - the relevance of relational contracts in doing business.

PERSONAL FINANCE

Master degree in Statistical Science
Language: English
Teaching period: First Trimester
Lecturer: Guglielmo Weber
Credits: 6 ECTS
Examination: oral

Personal finance (also known as household finance) asks how households actually invest, and how they should invest. It tackles the issues of participation in financial markets and of portfolio diversification. It further investigates financial investment issues that are particularly relevant for individuals or households: housing and mortgage decisions, consumer credit, and investment in private pensions. The first half of the course will be devoted to the standard model, where individuals maximize expected life-time utility subject to a number of constraints. The second half of the course will instead introduce an alternative approach, known as behavioural finance. Behavioural finance builds upon some descriptive models for decision making under risk recently developed by psychologists, focusing on prospect theory, cumulative prospect theory and on the concepts of loss aversion, probability distortion, and mental accounting. This part of the course will provide a description of market anomalies and inefficiencies, and discuss some psychological biases and limits of real investors that might generate those anomalies. It will then present behavioural models for portfolio selection that can explain these anomalies, also discussing how they can be integrated into the advisory process of banks.
INORGANIC CHEMISTRY FOR ADVANCED TECHNOLOGY

Bachelor degree in Chemistry
Language: English
Teaching period: Second Semester
Lecturer: Vito Di Noto
Credits: 6 ECTS
Examination: oral

Preparation, properties and applications of inorganic systems adopted in advanced technologies such as microelectronics, energy conversion etc. The main topics comprise: properties, refinement procedures, economic relevance and applications of elemental silicon (metallurgical and electronic grade silicon, ferrosilicon). Silicon halides, carbides and nitrides, silanes and metal silicides. Silicic esters, silicones, silicone copolymers and silicates. Properties, separation and applications of components of liquid air. Fundamentals of DMA and BES techniques for the investigation of mechanical and electrical properties and relaxations of materials.