ACADEMIC YEAR 2016-2017:

First semester: October 3rd, 2016 to January 20th, 2017
Winter exams session: January 23rd, 2017 to February 24th, 2017
Second semester: February 27th, 2017 to June 9th, 2017
Summer exams session: June 12th, 2017 to July 21st, 2017
Extra exams session: August 21st, 2017 to September 22nd 2017

ERASMUS MASTER DEGREES AND MASTER DEGREES WITH A PROGRAM OF COOPERATION WITH OTHER EUROPEAN UNIVERSITIES

1. ASTROMUNDUS
see information on http://www.astro.unipd.it/astromundus/

2. ALGANT (Algebra, Geometry And Number Theory)
see information on 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/
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The texts not yet updated are highlighted in yellow, but will soon be updated
1. **Astronomical Spectroscopy**
   Master degree in **Astronomy**, Second semester
   Lecturer: Piero Rafanelli
   Credits: 6 ECTS
   **Prerequisites:**
   Basic Physics I and II, Calculus I and II, Atomic Physics, Astrophysics I – II
   **Short program:**
   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.
   **Examination:** Oral exam, eventually integrated by the presentation of a topic related to the program we agreed in advance with the teacher.
   **More information:**

2. **Celestial Mechanics**
   Master degree in **Astronomy**, Second semester
   Lecturer: Stefano Casotto
   Credits: 6 ECTS
   **Prerequisites:** Students are expected to be familiar with Rational Mechanics and Mathematical Analysis, including the elementary theory of Ordinary Differential Equations. A fair amount of curiosity about dynamical phenomena observed in the Solar and other planetary systems is useful, together with an interest in their precise modeling and computation and the design of exploration missions.
   **Short program:**
   1. The equations of motion of gravitating systems
   2. The Two-Body Problem and an initial value problem (IVP)
   3. The Two-Body Problem and a boundary value problem (BVP)
   4. Orbital maneuvers
   5. Space and time reference systems
   6. The computation of a Keplerian ephemeris
   7. Preliminary orbit determination
   8. Keplerian relative motion and its generalization
   9. Regularization and Universal Formulation of the Two-Body Problem
   10. The TBP as a boundary value problem (BVP) – Lambert targeting
   11. The Problem of Three Bodies and its homographic solutions
3. Cosmology

Master degree in Astronomy, Second semester
Lecturer: Alberto Franceschini
Credits: 6 ECTS

Short program:

0. The Homogeneous and Isotropic Universe

1. The Large Scale Structure of the Universe. Local properties

2. Gravitational lensing

3. Cosmological evolution of perturbations in the cosmic fluid.

4. Peculiar motions of galaxies and structures.

5. Brief thermal history of the Universe

6. The Cosmic Microwave Background
Discovery of the CMB. Observations from ground and from space. COBE, WMAP & Planck. Origin of the CMB.

7. The Primordial Universe, Big Bang, phase transitions, cosmological inflation

8. Origin and Evolution of the Cosmological Structure

9. The Post-Recombination Universe
Intergalactic diffuse gas. Absorption-lines in quasar spectra. The missing baryon problem. Evolutionary history of star formation, the stellar mass function, heavy elements, back.

More information:

4. Galaxy Dynamics
Master Degree in Astronomy, Second Semester
Lecturer: Enrico Maria Corsini
Credits: 6 ECTS
Prerequisites:
Basic knowledge of Physics, Astronomy, Astrophysics, and Numerical Analysis.

Short program:

Examination: Oral exam.
More information:
5. High Energy Astrophysics
Master degree in Astronomy, First semester
Lecturer: Alberto Franceschini
Credits: 6 ECTS

Short program:
1. FUNDAMENTALS OF CLASSICAL ELECTRODYNAMICS. Basic formulae of electromagnetism in the classical limit. Electromagnetic waves. The relationship of electric charges and the radiation fields (radiations from moving charges, Lienard-Wieckert potentials, fundamental equation, Larmor, dipole emission, multi-polar contributions, the radiation spectrum.
6. COSMIC RAYS AND ACCELERATION MECHANISMS. Observational properties of cosmic rays. Fermi first-order and second order acceleration mechanisms.

11. **THE COSMIC PHOTON-PHOTON AND PARTICLE-PHOTON OPACITIES.** Extragalactic background radiations, background energy density. The photon opacity, applications to current and future observations.

**Examination:** Oral discussion.

**More information:**

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12. **Laboratory of Astrophysics 1**

- **Degree in Astrophysics, First Semester**
- **Lecturer:** Roberto Ragazzoni
- **Credits:** 6 ECTS

**Prerequisites:**
Knowledge of the basis of physics and astronomy at the level of the Laurea in Astronomia.
Basic knowledge of scientific English.

**Short program:**
Recall of basic principles of optics and of image formation.
Nature of light and geometrical nature of thin lenses and of conical sections. Concept of stigmatic and non stigmatic imaging.
Optical copies and Lagrange invariant.
Relevance of the position and size of the stop in an optical system and its effects on the overall property.
Two mirrors telescope.
Schwarzschild, Cassegrain, Gregorian and Ritchey-Chretienne solutions.
The problem of the background in astronomical imaging and in particular in the infrared.
Definition of the thermal and non-thermal infrared portion of the spectra. Vignetting and Field of View in Cassegrain telescopes.
Oversizing and under-sizing of the secondary mirror and natural ability to reject ground-based thermal infrared.
Off-axis sections in ground and space-based optical telescopes. Collimation and pupil reimaging.
Difference between images formed by parabolic and spherical mirrors and the case of Arecibo-like design.
Examples of telescopes and instrumentation employing the various concepts devised.
Adaptive and Active Optics.
Basic definitions, Kolmogorov turbulence and isoplanatic angle, Fried's parameter and Greenwood frequency.
Concept of Multi Conjugated Adaptive Optics. Star and Layer Oriented approaches. Detectors Charge Coupled Devices Detectors, principles of working and basic parameters. Quantum Efficiency, Charge Transfer Efficiency, Read Out Noise.
I3-CCD principle of working and effects on the Poissonian apparent noise.
Concept of the Avalanche Photo Diodes and Quenching.
Laboratory
Poisson's spot, turbulence simulation and speckle formations.
Asiago Observatory
Speckle interferometry and possibly Kolmogorov turbulence.
**Examination**: Oral exam.

**More information:**


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### 13. Mathematical Physics

Master degree in **Astronomy**, Second semester  
Lecturer: Massimiliano Guzzo  
Credits: 6 ECTS  

**Short program:**

1. Ordinary differential equations: Cauchy theorem, phase-space flow, dependence on the initial conditions; linear equations; phase-portraits, first integrals; equilibrium points; linearizations, stable, center and unstable spaces.
2. Integrable systems: elementary examples from population dynamics, from Mechanics and from Astronomy; integrability of mechanical systems, action-angle variables, examples.
3. Non-integrable Systems: discrete dynamical systems, Poincare' sections; bifurcations, elementary examples. Stable and Unstable manifols, homoclinic chaos; Lyapunov exponents, the forced pendulum and other examples; Center manifolds and partial hyperbolicity. The three body-problem, the Lagrange equilibria, Lyapunov orbits, the tube manifolds.

THE FOLLOWING TOPICS (4) AND (5) ARE ONLY IN THE PART FOR THE STUDENTS OF THE SECOND CYCLE DEGREE IN ASTRONOMY

4. Linear PDEs of first and second order, well-posed problems, the vibrating string, 1-dimensional wave equation, normal modes of vibrations, heat equation, Fourier series, 2-dimensional wave equation, Laplace operator and polar coordinates, separation of variables, Bessel functions, eigenfunctions of the Laplacian operator.
5. Laplace operator and spherical coordinates, separation of variables, Legendre polynomials and associate functions, Spherical harmonics, multipole expansions, L2 operator-eigenvalues and eigenfunctions, complete solution of the wave equation in space, Schrodinger polynomials.

THE FOLLOWING TOPICS (6) ARE ONLY IN THE PART FOR THE STUDENTS OF THE SECOND CYCLE DEGREE IN MATHEMATICAL ENGINEERING

6. Examples and Applications: examples of analysis of three and four dimensional systems; limit cycles; the Lorenz system, the three-body problem; examples from fluid dynamics, non autonomous dynamical systems, chaos indicators, Lagrangian Coherent Structures.

**Examination**: Written exam.

**More information:**


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### 14. Stellar Populations

Master degree in **Astronomy**, Second semester  
Lecturer: Giovanni Carraro  
Credits: 6 ECTS  

**Prerequisites:**

Basic knowledge of stellar astrophysics: Stellar evolution, c-m diagrams, stellar photometry and spectroscopy, astrometry.

**Short program:**

Color magnitude diagrams.  
Luminosity-magnitude and temperature-color transformation. Effects of the interstellar reddening on the color-magnitude diagrams.  
The concept of stellar populations: Historical background.  
Stellar populations: Modern view.
The Galactic model by Eggen, Lynden-Bell and Sandage.
The galactic halo model from Searle and Zinn.
Stellar populations in the solar neighbor
The interstellar medium near to the Sun and the local bubble.
Population II.
Measurement of population II main parameters: reddening, distance, age, chemical content
Globular Clusters stellar populations
The concept of multiple stellar populations
The helium content of the population II stars.
The horizontal branch and the second parameter problem
The population I and the galactic disk. Open clusters and field population.
Stellar populations in dwarf Galaxies of the Local Group
The initial mass function.
Observational parameters of unresolved stellar population and their interpretation
Star formation History in galaxies
Basic principles of the chemical evolution of the stellar populations.

Examination: Oral.

More information:

15. Astrophysics 2 (also offered as Theoretical Astrophysics in the Master Degree in Astronomy)
Degree in Astronomy, Second semester
Lecturer: Paola Marigo
Credits: 6 ECTS

Prerequisites:
Elements of plane trigonometry, derivatives, integrals, basic knowledge of physics relating to previous courses.
Preparatory courses: Astronomy I (two years) and Astronomy II (model A, third year).

Short program:
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.
5. Nuclear reactions.
Nuclear energy generation (binding energy). Derivation of thermonuclear reaction rates (cross sections, tunnel effect, Gamow peak). Temperature dependence of reaction rates

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

7. Simple stellar models.
Polytropic 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 centre 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, nucleosynthesis. 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.

Examination: Oral/written examination on all topics covered during the course.

More information:

EVOLUTIONARY BIOLOGY
16. Ethology

Master degree in **Evolutionary Biology**, First semester
Lecturer: Andrea Augusto Pilastro
Credits: 6 ECTS

**Prerequisites:**
Good knowledge in evolutionary biology, ecology, genetics, and zoology (advanced undergraduate course level).

**Short program:**
Main topics will regard the link between animal behavior ecology and evolution, the development and control of behaviour: genes environment and neural mechanisms, the evolution of animal signals, adaptive responses to predators, foraging behaviour and optimality models, reproductive behaviour: male and female tactics, mating systems, parental care, sperm competition and sexual selection, sexual conflict, social behavior, kin selection.
17. **Evolution and Conservation**
Master degree in **Evolutionary Biology**, First semester
Lecturer: Andrea Augusto Pilastro
Credits: 6 ECTS
**Prerequisites:**
Good knowledge in evolutionary biology, ecology, genetics, zoology and botany (advanced undergraduate course level).

**Short program:**
While evolutionary biology has important theoretical and practical implications in conservation, it has often been neglected. The reason for this probably originates from the mistaken belief that evolution acts too slowly to be relevant on an ecological time scale. In this course we will combine the fields of evolutionary and conservation biology to emphasize the importance of evolutionary theories in conservation programs. This course will therefore 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 maximising genetic diversity during captive breeding programs and re-introduction schemes, effect of anthropogenic factors on evolutionary adaptation to local changes in the environment.

Plant diversity: the Plant Global Assessment; hotspots of plant biodiversity; plant Red List for Europe and Italy.
Causes of plant's extinction risk: impact of urbanization and agriculture on the habitat loss and degradation; introduction of Invasive Alien Species (IAS); pollution and diseases.
Climate warming: the case of Gymnosperms.
Plant conservation: in situ (LIFE projects); ex situ (Botanical gardens, Germplasm banks, Algae banks); germplasm conservation methods.

**Examination:** Evaluation based on written exam. Oral test possible if required by the student (please contact the teacher in advance).

**More information:**

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**MARINE BIOLOGY**

18. **Biodiversity and behavior**
Master degree in **Marine Biology**, First semester
Lecturer: Matteo Griggio
Credits: 8 ECTS
**Prerequisites:**
To successfully follow this course, it is desirable that the student has taken courses in ecology, and in particular in marine ecology, at different levels (population, community).

**Short program:**
Biodiversity: the concept of biodiversity, the diversity of organisms and the ecological systems in which they live. The key role of evolution in shaping biodiversity. Ecological pressures on the morphology and behaviour of marine species. Morphological and behavioural adaptations to different marine habitats (pelagic, benthic, abyssal, intertidal). Biodiversity as the web of complex interrelationships between organisms, the contribution of the study of animal behaviour to understanding the concept of biodiversity. The study of reproductive behaviour, parental care, mimicry and social life, using the most modern concepts of behavioural ecology. Anthropic pressures on marine species and marine habitats. Anthropic impacts on marine species behaviour.

**Examination:** The evaluation is a written test consisting of three open questions.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/IF0360/2013/000ZZ/1129629

19. **Molecular ecology and demography of marine organisms**
Master degree in **Marine Biology**, First semester
Lecturer: Lorenzo Zane
Credits: 7 ECTS

**Prerequisites:**
Basic knowledge of Population Genetics and Ecology.
Understanding of written and spoken English.

**Short program:**
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 will then 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. The analysis of recently published papers will allow the student to understand the information that can be obtained using the molecular approach, with particular attention to individual identification, genetic tagging, historical demography and analysis of population differentiation.

**Examination:** Written. Multiple choice questions and questions with short and essay type answers.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/IF0360/2013/000ZZ/1148579

**MOLECULAR BIOLOGY**

20. **Biochemistry**
Master degree in **Molecular Biology**, First semester
Lecturer: Ildiko' Szabo'
Credits: 8 ECTS

**Prerequisites:**
Basic level of biochemistry, cellular biology and physiology.

**Short program:**
The course will give an in depth knowledge of some aspects of modern, advanced biochemistry regarding protein import mechanisms into organelles (mitochondria, chloroplasts and peroxisomes) and the mechanisms of protein degradation pathways (via ub ubiquitination) including illustration of the importance of the above processes in plant and
animal physiology. Connected to these themes, mechanisms of photoprotection in higher plants will be treated. In addition, the study of membrane proteins (topology, structure, structure/function relationship) will be discussed with illustration of advanced techniques (various spectroscopies, EPR, 2D/PAGE), with particular reference to intracellular ion channels. In addition, the most important aspects of tumor metabolism will be discussed.

**Examination:** Written exam comprising open questions and multiple choice tests.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SC1175/2008/000ZZ/1148520

## 21. Genomics

Master degree in **Molecular Biology**, Second semester
Lecturer: Giorgio Valle
Credits: 9 ECTS

**Prerequisites:**
The content of the course has been defined keeping in mind the program of the first level degree in Molecular Biology of the University of Padua. In particular it is expected that the students have a good knowledge of Genetics, Molecular Biology and Bioinformatics. The course is in English, therefore the students should have a reasonable command of spoken and written English.

**Short program:**
This is a 9 credit course, 7 of which will be lessons, the remaining 2 will be practicals. Each title reported below corresponds to approximately two hours of classroom teaching plus four hours of home study. The lessons will be articulated as follows.

### Part 1.
Presentation of course and practicals
Introduction: Life, Biology, Information, Genomes, Evolution
History of genomics
Next Generation sequencing (NGS)
NGS: data formats for reads
Classical sequence alignment and assembly algorithms
NGS read alignment
Alignment formats: gff, sam and bam
Genome assembly with NGS data
Mate pair libraries and scaffolding
Metagenomics

### Part 2
Transcriptome: Northern, EST, Full length, Microarrays
RNAseq
Analysis of RNAseq data
Proteomics
miRNA, miRNA target prediction; lincRNA
Interactomics, and functional associations
Gene prediction, gene ontology and gene annotation
DNA methylation and methylome analysis
Histone modification and ChIP analysis

### Part 3
Analysis of human mutations and polymorphisms
22. **Models in genetic disease research**

Master degree in **Molecular Biology**, First semester
Lecturer: Mauro Agostino Zordan
Credits: 4 ECTS

**Prerequisites:**
The course consists in a series of specific seminars dealing with the general topic of genetic diseases and the model organisms employed to study the molecular mechanisms involved in the physiopathology of the diseases. Consequently, all of the courses entailed by the Master's degree are considered preparatory to this course.

**Short program:**
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.

**Examination:** 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.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SC1175/2008/000ZZ/1148524

23. **Molecular biology of development**

Master degree in **Molecular Biology**, Second semester
Lecturer: Francesco Argenton
Credits: 8 ECTS

**Prerequisites:**
Students should have already acquired a basic knowledge of eukaryotic cell biology, control of gene expression, differentiation, histology and developmental biology.

**Short program:**
History and problems of developmental genetics, Molecular cellular mechanisms controlling development, digital imaging quantification of genetic effects, fate mapping, signaling pathways and their function and visualization (FGF, TGFb, BMP, HH, Notch, Hypoxia, Hippo, STATs etc), induction of main axis (DV, AP and LR) in vertebrates and drosophila, examples in organ formation..

**Examination:** Essays on theoretical arguments treated during the course.
Lab tests of digital imaging applied to developmental biology.
Journal club presentation of a specific publication.
Report of lab activities.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SC1175/2008/000ZZ/1134638
24. **Molecular Genetics**
Master degree in **Molecular Biology**, First semester
Lecturer: Antonella Russo
Credits: 6 ECTS
Prerequisites:
The basic knowledge deriving from the subjects of the first year of the Master Degree.

Short program:
Mammalian DNA replication, replication stress and genome stability. Aneuploidy, poliploidy and the genetic control of chromosome segregation. (10 h)
Evolution of sex-chromosome divergence. The molecular mechanisms for dosage compensation of sex-chromosome associated genes: the classical paradigm and new insights. (10 h)
Genomic imprinting. Diseases associated to defects of the genomic imprinting (6 h)
A global critical discussion on the topics of the course and on main perspectives. (2 h)
Critical reading and critical discussion (16 h).

Examination: Oral discussion, the student can indicate the preference for English or Italian language.
More information:
http://en.didattica.unipd.it/offerta/2016/SC/SC1175/2008/000ZZ/1134637

**SANITARY BIOLOGY**

25. **Biochemistry of Diseases**
Master degree in **Sanitary Biology**, First semester
Lecturer: Luca Scorrano
Credits: 8 ECTS
Prerequisites:
Biochemistry, Physiology and Pathology.

Short program:
1. Introduction to the course
2. Mechanisms of protein homeostasis
3. Mechanisms of cellular ion homeostasis
4. Mechanisms of redox homeostasis and cellular bioenergetics
5. Biochemical mechanisms of reversible cellular damage
   a. atrophy
   b. hypertrophy
   c. Metaplasia (EMT)
6. Biochemical mechanisms of irreversible cellular damage
   a. apoptosis
   b. necrosis
   c. necroptosis
   d. Autosis
7. Biochemical mechanisms of senescence and aging
8. Biochemical mechanisms of cell transformation and oncogenesis
9. Role of biochemistry in mitochondrial disease
These topics will be covered in specific workshops, Journal Clubs, lectures held by the teacher
and by ad-hoc invited international experts.

Tutorials
Laboratory tutorials on biochemical assays of cell death and autophagy and on the analysis of mitochondrial dysfunction.

**Examination:** Evaluation of the reports handled to the teachers during the course. A final written exam (multiple choice+small essays) might be foreseen under particular circumstances.

**More information:**

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26. **Human physiology**

Master degree in **Sanitary Biology**, First semester
Lecturer: Luigi Bubacco
Credits: 9 ECTS

**Prerequisites:**
Biochemistry and General Physiology.

**Short program:**
The Central Nervous System (8 hours)
Neurons: Cellular and Network organization and Properties,
Efferent Division: (10 hours) Autonomic and Somatic Motor Control. Sensory Physiology.
Muscles physiology (8 hours) Control of Body Movement
Cardiovascular Physiology (10 hours) Blood Flow and the Control of Blood Pressure and functional properties of Blood
Respiratory Physiology (8 hours) Mechanics of Breathing, Gas Exchange and Transport
The Kidneys (8 hours) Fluid and Electrolyte Balance
Digestion (8 hours) Energy Balance and Metabolism.
Endocrine Control of Growth and Metabolism (8 hours)
Reproduction and Development (8 hours)

**Examination:** Written exam, four questions to be answered in two hours.

**More information:**

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**INDUSTRIAL BIOTECHNOLOGY**

27. **Environmental biotechnology and bioenergy production**

Master degree in **Industrial Biotechnology**, First semester
Lecturer: Fiorella Lo Schiavo / Tomas Morosinotto
Credits: 8 ECTS

**Prerequisites:**
no specific prerequisites.

**Short program:**
Environmental Biotechnology:
Plant responses to mineral toxicity: Molecular Physiology of mineral nutrient, acquisition, transport and utilization. Aluminium toxicity, heavy metal ion toxicity (Cd+2, Hg2+, Pb2+). Phytoremediation approaches to remove soil/water contaminants.
Biotechnologies for Energy production:
Introduction: current energy sources and the necessity of renewable fuels.
Production of bioethanol from ligno-cellulosic biomasses.
Production of biodiesel from oleaginous crops.
Algae as biofuels producers. Evaluation of advantages and disadvantages with respect to plants.
Hydrogen production from algae and bacteria.
The biotechnological challenges for biofuels production: the optimization of conversion of solar into chemical energy.
Examples of genetic engineering for biofuels.
Exploitation of unicellular algae for wastewater treatment and bioremediation.

**Examination:** Oral discussion of the course contents and critical analysis of some recent scientific papers.

**More information:**

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**28. Environmental chemistry and genetic toxicology**

Master degree in **Industrial Biotechnology**, Second semester
Lecturer: Paola Venier
Credits: 8 ECTS

**Prerequisites:**
General and inorganic chemistry, Organic Chemistry, essentials of Life sciences and Genetics.

**Short program**
The following contents will be expanded or reduced according to the student skills and interest.


Part B (BIO). Variety of toxic agents and possible adverse effects at different levels of biological organization, with evidence-based facts and short mention to chemical toxicokinetics and toxicodynamics. Biological targets, measures of exposure, effect and susceptibility. Dose-response and time-response relationships, hormesis. Toxicological databases, criteria for the identification of toxic agents and their characterization, included biotechnological products and nanoparticles/nanomaterials. Physical agents: dose units, molecular effects and responses induced by non-ionizing and ionizing radiations; adaptive response, bystander effects, genetic/epigenetic mechanisms of genomic instability. Genotoxic, mutagenic and carcinogenic agents: genetic activity profiles, action mechanisms, mutational spectra, mutagenesis strategies. Other cases (e.g., reproductive toxicity, neurotoxicity, antimicrobial/antiviral activity). Methods of toxicology and toxicogenomics (practical experience, examples).

**Examination:** Oral or written evaluation depending on the student number. During the exam the student will also debate a free topic (toxic agent, biological process in terms of function/dysfunction, investigation method) agreed with the course teacher and based on the scientific literature. Effective reporting of biotechnological aspects will be positively evaluated.

**More information:**
29. **Immunological biotechnology**

Master degree in **Industrial Biotechnology**, First semester

Lecturer: Emanuele Papini / Regina Tavano

Credits: 8 ECTS

**Prerequisites:**
The student must have a good preparation in general Immunology.

**Short program:**
- 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 pediatric prevention in Italy
ADjuvants - Mucosal adjuvant- micro-nanosized new generation adjuvants.
- Use of dendritic cells in therapy: prespectives.

**Practical part:**
Evaluation in vitro of adjuvancy in human dendritic cells. Isolation of monocytes fromm blood, thier differentiation into Dendritic Cells (DCs). Stimulation of DCs with various adjuvants and analysis of cell activation by Elisa (TNFa) and flow cytometry (CD86, CD11), RT-PCR (tnfa gene transcription). Autologous/heterologous T lymphocytes proliferation and characterisation of their immunological competence by FACS.

**Examination:** Oral examination plus evaluation of a laboratory activity written report.

**More information:**

30. **Large-Scale Cell Cultures and Biomolecules Production**

Master degree in **Industrial Biotechnology**, Second semester

Lecturer: Chiara Rampazzo

Credits: 8 ECTS

**Prerequisites:**
Students are expected to have knowledge and competence of cellular and molecular biology and of biochemistry to be able to understand the fundamental aspects of mammalian large scale cell culture in upstream and downstream processes.

**Short program:**
Overview of the biopharmaceutical industry. Upstream and downstream processes. GMP/GLP regulatory requirements for processing biopharmaceuticals. Lab/pilot scale process to implement full manufacturing scale. Consistency and robustness in a fermentation process. Large scale mammalian cell culture. Cell line engineering techniques and common host cell lines used. Bioreactor operation mode: batch, fed batch, continuous and perfusion culture. Selection of bioreactor type (spinner flask, stirred tank). Attachment systems for cell cultivation in adhesion (plates, roller bottle, and stacked plate system) packed bed bioreactor, microcarriers, fluidized bed bioreactor, hollow fiber and wave bioreactor. Perfusion systems for cell cultivation (hollow fiber, spin filter, acoustic cell separation, alternating tangential flow (ATF) system). Design of cell culture medium without serum and with low content of proteins. Scaffold and matrix in bioreactors. How to calibrate oxygen, pH, nutrients and metabolites, cell density and viability in the bioreactor. Design of large scale cell culture process for mammalian cell culture. How to improve cell viability in a process. Expression of cloned proteins in mammalian cells, e.g. interferon and insulin. Large scale production of monoclonal antibodies and their use. Vaccine process development in mammalian cells and

**Examination:** Final exam will be oral. Students will be evaluated collegially by both professors.

**More information:**

**31. Nanobiotechnology**

Master degree in **Industrial Biotechnology**, First semester
Lecturer: Emanuele Papini / Alessandro Moretto
Credits: 8 ECTS

**Prerequisites:**
Basic background in chemistry and organic chemistry acquired in the previous fundamental courses. Basic knowledge about formation and properties of nanoparticles. Previous attendance of the "Nanosystems" course (I semester) is suggested.

**Short program:**

I. Introductory lessons that summarize the general features of nanoassembled systems; these lessons are meant to go over the main contents of the course "Nanosystems", for the benefit of those students who followed it; at the same time, they are meant to provide a basis for those student who do not have it. Outline of the essential features of nano-structured systems. The ideal nanostructure: components. Modified "natural" nanostructures (bacterial Outer Membrane Vesicles, viruses). Engineered nanoparticles: inorganic (silica, gold), organic (nanoformulations, polymers), liposomes and lipidic nanoparticles, quantum dots. Derivatization with small organic molecules (conjugation, orthogonal bioconjugation), with proteins or antibodies for specific cell targeting.


III. Bio-active (transported) portion and applications: drugs, immunostimulants, DNA. Direct action of the nanomaterial, photoactivation, magnetic field activation. Applications: fluorescent biomarking of tissues and cells, in vivo imaging, diagnosis. Drug and gene delivery.

Hyperthermal therapies. Separation and purification of biological molecules and cells. Contrast agents in magnetic resonance imaging (MRI). Phagokinetic studies.

IV. Laboratory. The practical part will be introduced by preparatory lectures. It will consist of the synthesis of nanosystems, among which will be nanoparticles (both organic and inorganic/metallic) coated with organic (charged) ligands; liposomes (some fluorophoric molecules will be encapsulated and released by appropriate stimuli); hydrogels based on amino acids and peptides. These nanosystems will be characterized using spectroscopic techniques, such as UV-vis, fluorescence, and dynamic light scattering. Next, the student will test the biocompatibility of the nanosystems produced in biological a-cellular (plasma) or cellular (stabilized human cell lines) models. Examples of possible characterization are: blood coagulation tests, complement activation, citotoxicity, cellular uptake.

**Examination:** The evaluation will be partly based on a written report on the experimental part, which will have to be turned in by the end of the course, and on an exam. The exam is written and consists of four open-answer questions on topics covered both in the practical and in the theoretical part of the course.

The time allotted to the discussion of the topics proposed is 2 hours.

**More information:**

32. **Nanosystems**

Master degree in **Industrial Biotechnology**, Second semester
Lecturer: Sabrina Antonello / Flavio Maran
Credits: 8 ECTS

**Prerequisites:**
B.Sc. level knowledge of Physical Chemistry and Organic Chemistry

**Short program:**
Part A. Physical chemistry and characterization of nanosystems.
Size matters: nanoscale dimension and quantum size confinement.
Intermolecular forces: electrostatic forces, dispersion forces, hydrogen bonds.
Physical chemistry of interfaces.
Thermodynamics of self-assembly and self-organization.
Amphiphilic molecules: thermodynamics for aggregation of micelles, bilayers, vesicles, biological membranes.
Electron and charge transfers.
Electrochemical techniques.
Scanning probe microscopies.
Optical microscopies and other surface characterization methods.
Part B. Properties and preparation of nanosystems.
Artificial and natural nanosystems.
Nanofabrication techniques.
Bottom-up approaches to nanosystem production.
Aggregates of amphiphilic molecules, nanoemulsions and organic nanoparticles.
Polymeric nanoparticles and dendrimers.
Stimuli-responsive nanosystems.
Carbon nanostructures (nanotubes, fullerenes, graphene).
Metal nanoparticles, nanoshells and nanorods.
Semiconductive nanoparticles : quantum dots.
Oxides nanoparticles : silica, titania.
Magnetic nanoparticles..

**Examination:** Written exam based on a series of tests, to be taken during the semester, and one final, to be taken on the first official date.

**More information:**

**CHEMISTRY**

### 33. Chemistry of organic materials

Master degree in **Chemistry**, Second semester  
Lecturer: Enzo Menna  
Credits: 6 ECTS  
**Prerequisites:**  
General Organic Chemistry.

**Short program:**
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 of materials  
- different kind of structures (polymers, oligomers, molecules, supramolecular systems and nanostructures)  
- synthesis and characterization of structures  
- structure-property relationships (e.g. effect of the substituent, of the supramolecular organization, ...)
- device fabrication techniques (e.g. thin layer deposition, self assembly of systems, ...)
- example of application both at research and commercial level.  
According to such scheme, the following topics will be considered in particular:
- Fullerenes, nanotubes and other carbon nanostructures  
- Organic photovoltaic devices  
- Organic electroluminescent materials (OLED)  
- Supramolecular polymers  
- Self assembled layers of organic molecules  
- Organic molecules for non-linear optics  
- Advanced biomimetic materials: dry adhesives (gecko effect) and self healing materials.  
- Structural organic materials: main classes of plastic and engineering polymers, their application, synthesis and properties..

**Examination:** Written.  
**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SC1169/2015/000ZZ/1145342

### 34. Electrochemistry

Master degree in **Chemistry**, First semester  
Lecturer: Flavio Maran  
Credits: 6 ECTS  
**Prerequisites:**  
B.Sc. level knowledge of Physical Chemistry, Organic Chemistry, and Analytical Chemistry

**Short program:**

**Examination:** Tests and final exam. Active participation during the lectures, including discussions.

**More information:**

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**35. Physical Chemistry 4**
Master degree in **Chemistry**, First semester
Lecturer: Alberta Ferrarini
Credits: 10 ECTS

**Prerequisites:**
B.Sc. level knowledge of Physical Chemistry and Physics.

**Short program:**
Part A.
Electric properties of molecules (dipole and higher order multipoles, polarizability) and their connection with the dielectric properties of matter. Applications: dielectric constant of liquids, electrostatic contribution to the solvation free energy.
Inter-molecular interactions: pair interactions and their expressions in terms of molecular quantities. Applications: lattice energy of ionic crystals, equation of state of van der Waals fluids.
Interaction of molecules with electromagnetic fields: time-dependent perturbation theory, transition probability, Fermi golden rule.
Classroom activities will also concern practical application of the methods introduced during the lectures.

Part B.
The first part concerns chemical kinetics: fundamental principles, temperature effect on chemical reactions, Arrhenius equation. Afterward, we will introduce: the Collision theory; the Transition-State theory; mass-transport mechanisms; homogeneous and heterogeneous catalysis. The second part of the course focuses on electrode kinetics, with particular emphasis on mass transport and charge transfer as the rate-determining steps. These analyses are addressed with reference to the most popular electrochemical methods. In the third part, the Marcus theory and further quanto-mechanical developments are described together with the distance effect on electron transfer and some applications to specific systems.
Finally, laboratory experiments have been devised to blend the above concepts on a practical standpoint.

**Examination:** Written and oral exams, as well as active participation in the course and associated laboratory experiments.
The written tests will focus on specific topics of the course, to facilitate a fast and progressive learning of the content of the classroom lectures.
The oral exam is meant to evaluate the students’ capability of utilizing the acquired skills and methodologies to address chemical problems.

**More information:**
36. **Physical Methods in Organic Chemistry**
Master degree in Chemistry, First semester
Lecturer: Ester Marotta
Credits: 6 ECTS

**Prerequisites:**
Good understanding of organic chemistry and basic concepts of NMR spectroscopy and mass spectrometry.

**Short program:**

**Examination:** Written test

**More information:**

37. **Theoretical Chemistry**
Master degree in Chemistry, Second semester
Lecturer: Antonino Polimeno
Credits: 6 ECTS

**Prerequisites:**
Basic knowledge in chemistry, physics and mathematics.

**Short program:**
The course will highlight the following subjects:
1. Classic (non-relativistic) mechanics methods for chemical systems
   - Hamilton principle, rigid body, Hamilton equations, canonical transformations, Poisson formulation
   - Molecular dynamics methods for the study of roto-translational motion in condensed phases
2. Quantum non-relativistic methods in chemistry
   - Basic ideas and links with classic approaches
   - Angular momenta
   - Group theory
   - Hartree-Fock, DFT, multiconfigurational approaches to electronic structures in molecules
3. Linear response theory
4. Stochastic approaches to molecular motions.

**Examination:** Oral and (optional) written paper on a chosen subject.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SC1169/2015/000ZZ/1145352

**INDUSTRIAL CHEMISTRY**

38. **Analytical Chemistry of Industrial Processes**
Master degree in Industrial Chemistry, Second semester
Lecturer: Marco Frasconi
Credits: 6 ECTS
**Prerequisites:**
Analytical Chemistry I and II, in particular knowledges of instrumental analysis.

**Short program:**
1) Introduction to Process Analytical Chemistry. Non-invasive methods of measuring; off-line, at-line, on-line and in-line measures. Acquirable types of signal, response times, instrumental, sampling and analysis times.
2) Quality in analytical measurements. The instrumental noise, types of noise and reduction strategies.
3) UV-visible and infrared spectroscopy for process analytical applications. Instrumentation design and sampling interface. Applications of infrared chemical imaging in the pharmaceutical industry.
4) On-line chromatographic techniques. Adsorption and desorption, active and passive sampling techniques.
5) On-line MS techniques. Examples from the pharmaceutical and food sector, and thin film deposition.
6) Automatic air quality analyzers. CO: non-dispersive IR, photoacoustic analyzer and FT-photoacoustic. NOx, SO2 and ozone. Details on interference management and calibration procedures.
7) Electrochemical sensors and biosensors. Examples of integrated sensor arrays for high throughput analysis.
8) Microanalytical systems. Overview of miniaturization of analytical instruments utilizing microfabrication technology. Application of on-chip detection techniques in bioanalytical studies.
9) Chemimetrics methods for process control and monitoring. Feedback optimization algorithms.

**Examination:** Oral examination.

**More information:**

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39. **Biopolymers**

Master degree in **Industrial Chemistry**, First semester
Lecturer: Stefano Mammi
Credits: 6 ECTS

**Prerequisites:**
None.

**Short program:**
The program is divided into the following points:
1) Polypeptides and protein macromolecules.
2) Polynucleotides
   Chemistry and stereochemistry of nucleotides. Typical properties of purine and pyrimidine bases and their derivatives. Primary, secondary, tertiary and quaternary structures of nucleic acids. Structural differences between DNA and RNA. Conformational analysis and forces that determine the structure of nucleic acids. PCR.
3) Polysaccharides
Chemistry and stereochemistry of structural units of polysaccharides. Structures of monosaccharides, disaccharides, homopolysaccharides, heteropolysaccharides. Mention of the structure of some peptidoglycan.

4) Industrial Biopolymers

5) Analytical techniques for the study of the structural properties of biopolymers.
Characterization and separation of biopolymers on the basis of their hydrodynamic properties: ultracentrifugation, diffusion, electrophoresis, light scattering, size exclusion chromatography. Spectroscopy applied to the study of biopolymers: absorption spectroscopy, circular dichroism, IR, fluorescence.

Examination: Oral.

More information:

40. Physical Methods in Organic Chemistry
Master degree in Industrial Chemistry, First semester
Lecturer: Ester Marotta
Credits: 6 ECTS
Prerequisites:
Good understanding of organic chemistry and basic concepts of NMR spectroscopy and mass spectrometry.

Short program:

Examination: Written test.

More information:
http://en.didattica.unipd.it/offerta/2016/SC/SC1169/2015/000ZZ/1126569

PHYSICS

41. Advanced Quantum Physics
Master degree in Physics, Second semester
Lecturer: Luca Salsnich
Credits: 6 ECTS
Prerequisites:
All the exams of the B.Sc. in Physics.

Short program:
1. Second quantization of the electromagnetic field.
Properties of the classical electromagnetic field in the vacuum.
Coulomb Gauge. Expansion in plane waves of the vector potential. Quantum oscillators and quantization of the electromagnetic field. Fock states and coherent states of the electromagnetic field. Electromagnetic field at finite temperature.
Absorption, stimulated and spontaneous emission of radiation:
Examination: Colloquium of about 30 minutes.

More information:

42. General Relativity
Master degree in Physics, Second semester
Lecturer: Gianguido Dall’Agata
Credits: 6 ECTS
Prerequisites:
Theoretical Physics is recommended.
Short program:
Riemannian geometry; Differential forms; the Principle of Equivalence; Einstein’s field equation; the Schwarzschild solution, the Newtonian limit; experimental tests; Maximally symmetric spaces; Schwarzschild black holes; More on black holes (Penrose diagrams, charged and rotating black holes); black hole Thermodynamics.
Examination: Questions on the topics presented during the course and solution of a simple problem.

More information:

43. Introduction to quantum electrodynamics
Master degree in Physics, Second semester
Lecturer: Pierpaolo Mastrolia
Credits: 6 ECTS
Short program:
Outline:
1. Quantum Electrodynamics: Feynman rules; scattering processes at tree-level; Rutherford scattering; Compton scattering.
2. Introduction to Renormalization and Regularization: Feynman parametrization, hard cutoff; dimensional regularization.
3. Examples of one-loop QED calculations: photon self-energy; electron self-energy, pole mass; the anomalous magnetic moment.
4. Renormalized perturbation theory: counterterms, two and three-point functions; renormalization conditions; Ward identities, decoupling of scalar photon polarization; running coupling.
5. Non-abelian gauge symmetries: covariant derivatives and field strengths, gauge kinetic terms; the SU(2) gauge theory; matter Lagrangian; Feynman rules; massive vector boson.
6. Spontaneous symmetry breaking: breaking of a discrete symmetry; spontaneous breaking of global U(1) symmetry; Goldstone theorem; the Higgs mechanism.
7. Introduction to the theory of electroweak interactions: SU(2) x U(1) gauge group; electroweak symmetry breaking and the Higgs doublet; the bosonic sector of the Standard Model, gauge and Higgs couplings; coupling to matter, charged and neutral weak currents; effective field theories and the Fermi theory of weak interactions.

Examination: Written and oral.


44. **Theory of fundamental interactions**
Master degree in **Physics**, First semester
Lecturer: Andrea Wulzer
Credits: 6 ECTS

**Prerequisites:**
An elementary knowledge of relativistic Quantum Field Theory and of the use of Feynman diagrams is required.

**Short program:**
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.

Examination: Oral exam, optional exercises.


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**GEOLOGY AND TECHNICAL GEOLOGY**

45. **Applied Geochemistry**
Master degree in **Geology and technical Geology**, First semester
Lecturer: Christine Marie Meyzen
Credits: 6 ECTS

**Prerequisites:**
All students must have a solid understanding of basic principles in chemistry, geology, mineralogy, igneous and metamorphic petrology.

**Short program:**
Isotope geochemistry plays an increasingly important role in a wide variety of geological, environmental, medical, forensic and archeological investigations. Isotope methods allow to
determine the age of the Earth, reconstruct the climate of the past, detect adulterated foods and beverages, detect and monitor the progress of diseases in human and explain the formation of the chemical elements in the universe. This course is designed to provide an introduction to the principles and applications of isotope geochemistry. Systems discussed include the classic radiogenic systems (Rb-Sr, Sm-Nd, Lu-Hf and U-Th-Pb), traditional (e.g. H and O) as well as nontraditional (e.g. Fe) stable isotope systems, cosmogenic isotopes and extinct radioactivities. Applications as chronometers or tracers will be focused on a wide range of topics ranging from processes and timescales relevant to the formation of the planet and solar system, the evolution of the Earth system to environmental issues.

**Examination**: Course learning goals will be assessed by written examinations.

**More information:**

46. **Applied Petrography**  
Master degree in **Geology and technical Geology**, First semester  
Lecturer: Claudio Mazzoli  
Credits: 6 ECTS  
**Prerequisites**: Basic knowledge in petrology, geochemistry and mineralogy.  
**Short program**:  
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.  
**Examination**: Oral test.  
**More information:**  

47. **Basin Analysis**  
Master degree in **Geology and technical Geology**, Second semester  
Lecturer: Massimiliano Zattin  
Credits: 6 ECTS  
**Prerequisites**: Basic knowledge of some courses of the first semester (Applied geophysics, Micropaleontology, Applied geochemistry).  
**Short program**:  
1) The foundations of sedimentary basins; classification and plate tectonics.  
2) Basins due to lithospheric stretching: rifts and passive margins.  
3) Basins due to lithospheric flexure: foredeep, foreland, buckling.  
4) Dynamic topography.  
5) Strike-slip and pull-apart basins.  
6) Subsidence and thermal history.  
7) Appication to petroleum industry.  
**Examination**: Written examination.  
**More information:**  

48. **Carbonate Sedimentology**  
Master degree in **Geology and technical Geology**, First semester  
Lecturer: Nereo Preto  
Credits: 6 ECTS  
**Prerequisites**:  

Knowledges of sedimentary geology and clastic sedimentology; base notions of chemistry.

**Short program:**
- The carbon cycle in the oceans, and some notions of physical oceanography;
- The precipitation of carbonates as a chemical and biological process;
- Origin of carbonate platforms and deep-water carbonates;
- Types of carbonate platforms, their depositional architectures, and their dynamic stratigraphy;
- Diagenesis of carbonates and reconstruction of diagenetic histories;
- Dolomitization processes;
- Stable isotope geochemistry, as applied to problems of carbonate diagenesis;
- Sequence stratigraphy of carbonates.

**Examination:** Written test.

**More information:**

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49. **Metamorphic Petrology**

Master degree in **Geology and technical Geology**, First semester

Lecturer: Bernardo Cesare

Credits: 6 ECTS

**Prerequisites:**
Basic knowledge of petrography, geochemistry and mineralogy.

**Short program:**
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.

**Examination:** Oral examination in English.

**More information:**

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50. **Micropaleontology**

Master degree in **Geology and technical Geology**, First semester

Lecturer: Claudia Agnini

Credits: 6 ECTS

**Prerequisites:**
Basic of Stratigraphy and Paleontology.

**Short program:**
History of micropaleontology and its position in the context of the geological sciences. Its developments and the importance of deep-sea drilling projects. The first part of the course deals with “pure” micropaleontology. An overview of the various microfossil groups of botanical and zoological origin, that are widely used both in academic research and oil and gas industry, by presenting their morphology, taxonomy, mode of life, environments and stratigraphic distribution. In this context, preparation- and research techniques of main microfossil groups and their geological importance in terms of dating, correlation, facies interpretation, paleoenvironmental and paleoclimatic reconstruction is introduced to the students.
The second part of the course consists of practical microscope exercitations on micropaleontological samples which contain the main microfossil groups presented in the general theoretical part (e.g., calcareous nannofossils, foraminifera, radiolarians, diatoms, ...).

**Examination:** Practical examination plus oral examination.

**More information:**

51. **Morphodynamics of lagoons, deltas and estuaries under climate change**

Master degree in **Geology and technical Geology**, First semester

Lecturer: Andrea D’Alpaos

Credits: 6 ECTS

**Short program:**

**Examination:** Written and Oral exam.

**More information:**

52. **Numerical modeling in Geosciences**

Master degree in **Geology and technical Geology**, First semester

Lecturer: Manuele Faccenda

Credits: 6 ECTS

**Prerequisites:**
Basic mathematics, physics and MatLab.

**Short program:**
1. Mathematical basis for partial differential equations (derivatives, gradient, divergency, laplacian operator)
2. Rock physical properties (viscosity, elastic moduli, cohesion and friction coefficient, density, thermal conductivity and diffusivity, heat capacity)
3. Synthetic phase diagrams and thermodynamical database implementation
4. Stress, strain and strain rate tensors and constitutive relationships.
5. Visco-elasto-plastic deformation
6. Diffusion equation
7. Conservation of mass
8. Conservation of momentum
9. Conservation of energy
11. Solution of systems of equation with iterative (Gauss-Siedel) or direct (Gauss elimination) methods.
12. Working with MatLab software to:
   - save, read and plot data
   - programming petrological-thermo-mechanical numerical codes with viscous deformation and variable physical properties

**Examination:** Oral and practical test.

**More information:**
53. **Petroleum Geology**
Master degree in **Geology and technical Geology**, Second semester
Lecturer: Massimiliano Zattin
Credits: 6 ECTS
**Prerequisites:**
Basic knowledge of some courses of the first semester (Sedimentology, Applied geophysics, Micropaleontology, Applied geochemistry).
**Short program:**
The course will delivery the key-concepts of petroleum geology and is integrated by seminars on specific topics (to be defined during the semester).
- The origin of petroleum; physico-chemical properties of hydrocarbons.
- The source rock, maturity of organic matter and petroleum migration.
- The seal rock.
- Reservoir geology, stratigraphic traps, structural traps.
- Main exploration and production techniques.
**Examination:** Written examination.
**More information:**

54. **Sedimentology**
Master degree in **Geology and technical Geology**, Second semester
Lecturer: Massimiliano Ghinassi
Credits: 6 ECTS
**Prerequisites:**
Basic knowledge concerning sedimentology (textural features of the main types of sediments and sedimentary rocks) and stratigraphy (temporal and spatial variability of depositional systems).
**Short program:**
Introduction to Sedimentology
- facies and facies associations
- textural features of sediments, stratal geometries and terminology
Sediment transport and deposition
- tractional transport from unidirectional currents
- tractional transport from oscillatory currents
- mass transport
Post-depositional modifications
- soft-sediment deformations
- ichnofossils
Depositional environment
- continental depositional environments (alluvial fan, fluval, lacustrine, eolian)
- coastal depositional environment (wave-dominated coasts, deltas, tidal flats/lagoons )
- deep marine depositional environment (turbidites, conturites)
Sequence stratigraphy
- base level and accommodation space
- systems tracts
- sequences
- incised valleys
- non-marine sequence stratigraphy
**Examination:** Written test (open questions).
COMPUTER SCIENCE

55. **Advanced Topics in Computer Science**

Master degree in **Computer Science**, Annual  
Lecturer: Francisco Javier Cazorla Almeida, Seth Tucker Taft  
Credits: 6 ECTS  
**Prerequisites:**  
No prerequisites.  
**Short program:**  
The course consists of series of lectures, illustrating advanced topics in computer science with the support of international experts.  
**Examination:** The student will deepen some chosen theme. A discussion in the form of a seminar or the development of a related project will then be used to assess to what extent the student masters the subject.  
**More information:**  

56. **Bioinformatics**

Master degree in **Computer Science**, First semester  
Lecturer: Giorgio Valle  
Credits: 6 ECTS  
**Prerequisites:**  
There are no particular prerequisites other than what it is expected from a master student in informatics. Basic knowledge of genetics and molecular biology will help in the understanding of the biological motivations of bioinformatics.  
As the course is given in English, the students should have a reasonable command of spoken and written English.  
**Short program:**  
This is a six-credit course: five credits will be from lessons while one credit will be from practical activities, such as the implementation and of some algorithm or the in-depth investigation of the literature on given arguments.  
The lessons are 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 used to introduce some biological problems that require computational approaches and bioinformatics tools.  
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.  
**Examination:** The exam will be oral, but a continuous process of assessment will be carried out throughout the course, to verify the level of understanding of the students.  
**More information:**  
57. **Computer and Network Security**
Master degree in **Computer Science**, First semester
Lecturer: Mauro Conti
Credits: 6 ECTS
**Prerequisites:**
No strict prerequisites on previous exams.
However, it is suggested to have basic knowledge of networking, cryptography, and distributed systems (typically acquired in BSc degrees in Computer Science).

**Short program:**
4) **PART FOUR CRYPTOGRAPHIC ALGORITHMS:** Symmetric Encryption and Message Confidentiality, Public-Key Cryptography and Message Authentication.

The second part of the course takes the form of seminars based on a selection of scientific papers (that either have had a strong impact on security today, or explore novel ideas that may be important in the future).

**Examination:** Written.

More information:

58. **Cryptography**
Master degree in **Computer Science**, First semester
Lecturer: Alessandro Languasco
Credits: 6 ECTS
**Prerequisites:**
The topics of the following courses: Algebra, Calculus.

**Short program:**

**Examination:** Written exam.

More information:

59. **Functional Languages**
Master degree in **Computer Science**, First semester
Lecturer: Gilberto Filè  
Credits: 6 ECTS  
**Prerequisites:**  
Imperative and object oriented programming.  
**Short program:**  
Two functional languages are taught: ML and especially Haskell.  
Pattern matching;  
Curryfied and higher-order functions;  
Type inference: what it is and how it is done;  
Polymorphism;  
Lazy evaluation;  
Functors, applied functors and monads;  
Exceptions and I/O;  
Run-time support.  
**Examination:** The exam has a written and an oral part. Each part counts for 50% of the grade. The written part is on the general concepts taught in the course, whereas the oral part is a discussion on homeworks assigned during the course.  
**More information:**  

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**60. Methods and Models for Combinatorial Optimization**  
Master degree in **Computer Science**, First semester  
Lecturer: Luigi De Giovanni, Marco Di Summa  
Credits: 6 ECTS  
**Prerequisites:**  
Basic notions of Operations Research, Linear Programming, and computer programming.  
**Short program:**  
1. Advanced linear programming and duality with applications: primal-dual simplex, column generation, applications to network optimization.  
2. Advanced methods for Integer Linear Programming (ILP): Branch & Bound and relaxation techniques, alternative ILP formulations, cutting planes method and Branch & Cut, application to relevant examples (Traveling Salesman Problem, location, network design etc.).  
4. Application of graph modeling and optimization.  
5. Labs: optimization software packages and libraries.  
**Examination:** Oral examination about course contents. Each student may chose to present a short project concerning models and exact/heuristic solution methods for a realistic application of combinatorial optimization.  
**More information:**  

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**61. Mobile Programming**  
Master degree in **Computer Science**, Second semester  
Lecturer: Armir Bujari  
Credits: 6 ECTS  
**Prerequisites:**  
No prerequisites.  
**Short program:**
History of mobile application frameworks
Characteristics of mobile applications
Application models of mobile application frameworks
User-interface design for mobile applications
Managing application data
Integrating with cloud services
Publishing, deployment, maintenance, and management.

**Examination:** The exam will require the development of a project and an oral test.

62. **Security and Risk Management**
Master degree in **Computer Science**, First semester
Lecturer: Roberto Di Pietro
Credits: 6 ECTS

**Prerequisites:**
Notions of
- ICT security
- computer networks
- operating systems.

**Short program:**
IT Audit Principles:
- Risk analysis
- Objectives
- Planning
- Evidence gathering
- Conclusions and recommendations;
- Audit report
IT Audit: Standard and methodologies
- Current certifications schemes;
- CISA (Certified Information Security Auditor) methodology
IT Governance principles
IT Governance Framework, strategic alignment;
Value Delivery, Risk Management;
Resource Management, Performance Measurement.

**Examination:** Written exam.
**More information:**

63. **Wireless Networks**
Master degree in **Computer Science**, First semester
Lecturer: Claudio Enrico Palazzi
Credits: 6 ECTS

**Prerequisites:**
Computer Networks.

**Short program:**
Introduction to Wireless Networks.
Wireless network issues: error and collision losses, fairness and transmission delays, handoffs.
MAC layer standards: 802.11 a/b/g/n/p/s
Transport protocols in wireless environments: TCP Vegas, TCP Westwood, TCP Hybla, CUBIC.
Ad hoc networks and routing protocols: MANET, VANET, DSDV, AODV, DSR.
Applications and services on mobile networks.

**Examination:** Students are evaluated through individual/team projects and oral finals focused on all the topics discussed in class.

**More information:**

**MATHEMATICS**

64. **Algebraic Geometry 1**
   Master degree in **Mathematics**, Second semester
   Lecturer: Bruno Chiarellotto
   Credits: 8 ECTS
   **Prerequisites:**
   Basic commutative algebra and basic geometry of the first 3 years in math.
   **Short program:**
   Schemes, sheaves and basic algebraic geometry.
   **Examination:** Written.
   **More information:**

65. **Algebraic Geometry 2**
   Master degree in **Mathematics**, Second semester
   Lecturer: Carla Novelli
   Credits: 6 ECTS
   **Prerequisites:**
   Galois theory; Commutative algebra. Students are not required to have already taken Algebraic Geometry 1, but it is assumed that are following that course.
   **Short program:**
   Birational geometry.
   Birational geometry of curves and surfaces.
   Singularities.
   Introduction to the minimal model program.
   **Examination:** Written exam consisting of short and extended answer questions.
   **More information:**

66. **Commutative Algebra**
   Master degree in **Mathematics**, First semester
   Lecturer: Marco Andrea Garuti
   Credits: 8 ECTS
   **Prerequisites:**
   Basic notions of algebra (rings, ideals, fields, quotients, etc.), as acquired in the class "Algebra 1" course.
   **Short program:**
   Modules, submodules and their operations (sums, intersection). Annihilator of a module. Faithful modules. Direct sums and direct products of modules. Exact sequences of modules,

**Examination:** - A compulsory written test for everyone.

**More information:**

67. **Complements of Numerical Analysis**
Master degree in **Mathematics**, Second semester
Lecturer: **NO LECTURER ASSIGNED TO THIS COURSE UNIT**
Credits: 6 ECTS

**Prerequisites:**
The course requires a basic knowledge of calculus, linear algebra and numerical analysis.

**Short program:**
Course unit contents:
The various topics developed at different levels will be
1. Formal orthogonal polynomials
   - Definition
   - Algebraic properties
   - Recurrence relation
   - Adjacent Families
2. Padé approximation
   - Definition and algebraic properties
   - Padé-type approximants
   - Connection to formal orthogonal polynomials
   - Recursive computation
   - Connection to continued fractions
   - Some elements of convergence theory
   - Applications
3. Krylov subspace methods
   - Definition
   - Lanczos method
   - Recurrence relations
   - Implementation
4. Extrapolation methods
   - Sequence transformations and convergence acceleration
   - What is an extrapolation method?
Various extrapolation methods
- Vector sequence transformations
- Applications
  i. Treatment of the Gibbs phenomenon
  ii. Web search
  iii. Estimation of the error for linear systems
  iv. Regularization of linear systems
  v. Estimation of the trace of matrix powers
  vi. Acceleration of Kaczmarz method
  vii. Fixed point iterations
  viii. Computation of matrix functions

Examination: The final exam will be a written test on the topics of the course or a small research project.

68. **Complex Analysis**
Master degree in **Mathematics**, Second semester
Lecturer: Pietro Polesello
Credits: 6 ECTS
Prerequisites:
- undergraduate courses in Calculus and Geometry
- elementary notions on complex functions of one complex variable. In particular:

Short program:
The Argument principle and applications.
The Schwarz reflection principle.
Conformal maps and the Riemann Mapping theorem.
Runge's theory and applications.
Partial Fraction Decompositions and Mittag-Leffler's theorem.
Infinite products and the Weierstrass factorization theorem.
Principal ideals of holomorphic functions.
Some special functions (Gamma, Zeta).
The Prime Number theorem.

Examination: Written exam with possible additional oral exam.

69. **Cryptography (also offered in the Master Degree in Computer Science)**
Master degree in **Mathematics**, First semester
Lecturer: Alessandro Languasco
Credits: 6 ECTS
Prerequisites:
The topics of the following courses: Algebra, Calculus.

Short program:


Examination: Written

More information: 

70. Functions of Several Complex Variables
Master degree in Mathematics, First semester
Lecturer: Luca Baracco
Credits: 6 ECTS

Prerequisites:
Basics on functions of one complex variable, differential calculus, differential geometry.

Short program:
1. Real and complex differentials
2. Cauchy formula on polydiscs
3. Subharmonic functions
4. Separate analytic functions
5. Analytic functions and convergent power series
6. Levi form and H. Lewy’s extension theorem
7. Logarithmic Superharmonicity, Continuity principle, Propagation of holomorphic extendibility
8. Domains of holomorphy end pseudoconvex domains
9. L2 estimates and Neumann problem

Examination: Oral.

More information: 

71. Functions Theory
Master degree in Mathematics, First semester
Lecturer: Pierdomenico Lamberti
Credits: 8 ECTS

Prerequisites:
Measure Theory and Lebesgue integration: basic definitions, classical theorems for passing to the limit under integral sign, Tonelli and Fubini Theorems, basic notions on L^p spaces.

Short program:

Examination: Written and Oral.
72. Harmonic Analysis
Master degree in Mathematics, Second semester
Lecturer: Peter Sjogren
Credits: 6 ECTS

Short program:
The lecture course is mainly devoted to the theory of singular integrals. Singular integral theory has its roots in the early 20th century and in complex function theory. In the 1950's, it was extended to real Euclidean spaces of arbitrary finite dimension, and linked to the Laplacian and other elliptic operators. It turned out to be a very useful tool to treat many partial differential equations, and this led to more general versions. The theory still relied heavily on Fourier analysis for the basic L^2 estimate. But in the 1980's, other methods were developed to deal with the L^2 case, the so-called T1 theorem and generalizations of it. This meant vast extensions of the theory and its applications.

The course will start with the Hilbert and Riesz transforms, which is the classical theory, related to analytic functions and the Laplacian. These operators are invariant under translation, and given by a convolution kernel. Necessary notions such as weak L^p spaces, the Hardy-Littlewood maximal operator and real interpolation will be introduced. Then the Calderón-Zygmund decomposition will be given, as a fundamental tool to go from L^2 to L^p estimates. Here the singular integrals need not be translation invariant, and their kernels will depend on two variables. The space BMO (bounded mean oscillation) will then be defined, studied and applied to the singular integrals. This will allow us to state the important T1 theorem. Its proof requires the development of some tools, like Cotlar's lemma and Carleson measures.

If time allows, we may move to some other model of harmonic analysis, defined in terms of expansion in classical orthogonal polynomials. These models are quite important in both classical and modern physics. There we shall deal with Riesz transforms and other singular integrals.

Examination: Oral.

More information:

73. Introduction to group theory
Master degree in Mathematics, First semester
Lecturer: Andrea Lucchini
Credits: 8 ECTS

Prerequisites:
Basic knowledge in general algebra

Short program:
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.
 Examination: Oral. The candidate will be asked to present the most important arguments presented in the course, proving the more significant results and solving some related exercise.


74. Introduction to Partial Differential Equations
Master degree in Mathematics, First semester
Lecturer: Fabio Ancona
Credits: 8 ECTS
Short program:
Didactic plan:
- Maximum principle for degenerate elliptic operators.
- Wave equation: existence of solutions, D'alembert formula, uniqueness, finite speed of propagation.
Examination: The exam consists of a final oral examination on the topics treated in class. There will be both theoretical questions and the discussion of some exercise to solve.

75. Introduction to Ring Theory
Master degree in Mathematics, First semester
Lecturer: Alberto Facchini
Credits: 8 ECTS
Prerequisites: Courses of “Algebra 1” and “Algebra 2”. That is, standard undergraduate Algebra.
Short program:
Examination: Oral examination and/or evaluation of the exercises solved by the students during the course.

76. Numbers theory1
Master degree in Mathematics, First semester
Lecturer: Francesco Baldassarri  
Credits: 8 ECTS  
**Prerequisites:**  
A standard Basic Algebra course; the experience of a short course in Galois Theory would be most useful; Linear Algebra; Notions of Calculus; some familiarity with complex functions of one variable might be useful.  
**Short program:**  
1. Basic algebra of commutative groups and rings.  
2. Factorization of elements and ideals  
3. Dedekind domains  
5. Rings of integers. Factorization properties.  
7. Frobenius automorphism, Artin map;  
9. An introduction to Class Field Theory (from Kato-Kurokawa-Saito Vol. 2, Chap. 5)  
10. Minkowski Theory (finiteness of class number and the unit theorem).  
11. Dirichlet series, zeta function, special values and class number formula (from Kato-Kurokawa-Saito, Vol. 1).  
The whole material is to be found in the single textbook: Daniel A. Marcus "Number Theory", Springer-Verlag. Our essential program consists of Chapters 1 to 5, with those exercises which are used in the body of the textbook. The complex-analytic proofs in Chapter 5 will not be required.  
We recommend, for cultural reasons, reading through the two volumes of Kato-Kurokawa-Saito, possibly without studying proofs.  
**Examination:** Three written partials will be proposed during the course. They are supposed to check the step-by-step understanding of the course by the students. A final all-inclusive exam will be proposed for those who have not passed the partials or are not satisfied with the grades.  
Each student will be invited to present one topic agreed with the teacher in a 45 minutes lecture during the course. A final oral examination is reserved for those who aim at top grades.  
**More information:**  

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77. **Number Theory2**  
Master degree in Mathematics, Second semester  
Lecturer: Adrian Iovita  
Credits: 6 ECTS  
**Prerequisites:**  
Basic notions of algebraic number theory and Galois theory.  
**Short program:**  
1) ramification theory of finite extensions, Galois $K/L$, where $K,L$ are local fields (references to J.-P. Serre, Corps Locaux/Local Fields).  
2) p-adic representations of $G_K$, with $K$ a $p$-adic local field.  
3) p-adic representations of $G_K$ (K $p$-adic local field) which are $C_p$-admissible (references to J.Tate, p-Divisible groups).  
4) Dwork’s proof of Weil conjectures.  
**Examination:** Written/oral.  
**More information:**  
78. **Representation Theory of Groups**
Master degree in Mathematics, Second semester
Lecturer: Giovanna Carnovale
Credits: 6 ECTS
**Prerequisites:**
Basic notions of linear algebra and group theory.
**Short Program:**
**Examination:** Written, involving a series of exercises.
**More information:**

79. **Rings and Modules**
Master degree in Mathematics, Second semester
Lecturer: Silvana Bazzoni
Credits: 6 ECTS
**Prerequisites:**
Notions from the Algebra courses of the first two years of the degree in Mathematics and basic notions on module theory over arbitrary rings.
**Short Program:**
**Examination:** Written exam with a discussion on the composition.
**More information:**

80. **Stocastic Methods for Finance**
Master degree in Mathematics, Second semester
Lecturer: Martino Grasselli
Credits: 7 ECTS
**Prerequisites:**
None.
**Short Program:**
The pricing problem in the binomial models
Risk neutral pricing in the discrete time world
European and American options in the binomial model.
Arbitrage and risk neutral pricing in continuous time.
Pricing of contingent claims in continuous time: the Black&Scholes formula.
Black&Scholes via PDE and via Girsanov.
Hedging and completeness in the Black&Scholes framework.
Feynman-Kac formula and risk neutral pricing in continuous time.
Pur Call parity, dividends and static vs dynamic hedging.
The Greeks and the Delta-Gamma hedging. Delta-Gamma-Vega neutral portfolios.
Barrier options pricing in the Black&Scholes model.
Quanto option pricing in the Black&Scholes model.
Multi asset markets, pricing and hedging.
Exchange options pricing in the multi-asset Black&Scholes model.
Incomplete markets: quadratic hedging.
Smile and skew stylized facts.
Beyond the Black&Scholes model: stochastic volatility.
The Heston model.
Bonds and interest rates. Pre-crisis and multiple-curve frameworks.
Short rate models, Vasicek, CIR, Hull-White models, affine models.
Cap&Floor pricing in the short rate approaches. The pricing of swaptions.
Forward rate models: HJM approach, the drift condition and BGM models.
Change of numeraire and Forward Risk Neutral measure.
LIBOR and Swap models.
Examination: Written and oral.

81.  Symplectic Mechanics
Master degree in Mathematics, First semester
Lecturer: Franco Cardin
Credits: 6 ECTS
Prerequisites:
Elementary Calculus and Geometry
Short program:
Cohomology.
Riemannian manifolds: Existence of metrics, Whitney theorem.
Symplectic Geometry: Symplectic manifolds.
Introduction and developments of Hamiltonian Mechanics on symplectic manifolds.
Local and global parameterization of the Lagrangian submanifolds and their generating functions. Theorem of Maslov-H"ormander.
Hamilton-Jacobi equation, its geometrical solutions and links to the Calculus of Variations.
Conjugate points theory in calculus of variations.
Relative cohomology and Lusternik-Schnirelman theory. Introduction to Symplectic Topology: existence and classification of critical points of functions and applications to generating functions of Lagrangian submanifolds.
The min-max solution of Hamilton-Jacobi equation. Symplectic Topology by Viterbo: towards the solution of the Arnol'd conjecture. Morse theory.
Examination: Written.

82.  Theory of Approximation and applications
Master degree in Mathematics, First semester
Lecturer: Stefano De Marchi
Credits: 7 ECTS
Prerequisites:
The course requires the basic courses of Numerical Calculus and Numerical Analysis. It is also useful to have attended a course of Functional Analysis. It is assumed that the students know the programming language Matlab.

**Short program:**
The course can be subdivided in 2 theoretical parts of 24h each, in total 48h corresponding to 6CFU. Moreover there will be 16h of lab exercises.

**PART I (20h+6h): polynomial approximation**
- best approximation approximation
- modulus of continuity and Lebesgue constant
- nearly optimal distribution of points in 1-dimension
- Padua points for interpolation and cubature
- (Weakly) admissible meshes
- applications and lab (6h)

**PART II (28h+10h): Radial Basis Functions (RBF)**
- learning from splines
- positive and conditionally definite functions
- native spaces, power function and error estimates
- application to the solution of elliptic PDEs
- applications and lab (10h).

**Examination:** The final exam is a written test on the topics of the course. There will be also an oral part in which the student will discuss the lab exercises given during the course.

**More information:**

83. **Topology 2**
Master degree in **Mathematics**, First semester
Lecturer: Andrea D'Agnolo
Credits: 6 ECTS

**Short program:**
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.
Sheaves on topological spaces 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.

**Examination:** Oral.

**More information:**

**MATERIALS SCIENCE**

84. **Computational Methods in Materials Science**
Master degree in **Materials Science**, Second semester
Lecturer: Francesco Ancillotto/ Alberta Ferrarini
Credits: 6 ECTS

**Prerequisites:**
Quantum and solid state physics, physical chemistry.

**Short Program:**
Basic concepts of thermodynamics and classical statistical mechanics.
Classical Molecular Dynamics simulations; numerical integration of Newton equations.
Monte Carlo method; Metropolis algorithm.
Simulations in various statistical ensembles.
Common features of simulations methods: initial and boundary conditions; calculation of inter-particle interactions.
Calculation of thermodynamic and transport properties.
Intermolecular interactions: force-fields; atomistic and coarse grained models.
Variational methods for the solution of the Schrodinger equation.
Hartree and Hartree-Fock theory.
Elements of Density Functional Theory (DFT).
'First principles' simulations.

The different computational methods will be discussed in relation their application to topics of interest for material science (crystals, surfaces, soft matter, nanostructured materials).
In the computer exercises, students will carry out simple simulations, using software packages that are currently employed in materials science, and they will learn how to interpret and present the results of simulations.

**Examination:** Oral examination in which the students will discuss a written report, on the results of simple numerical simulations.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SC1174/2015/000ZZ/1145477

85. **Nanofabrication**
Master degree in **Materials Science**, First semester
Lecturer: Filippo Romanato
Credits: 6 ECTS

**Prerequisites:**
Single-cycle degree.

**Short program:**
Many of the impressive technical and scientific progress of the last two decades and 'based on the ability' to control individual chemical and physical phenomena at the level of a few nanometers that 'the scale of size which occurs most natural phenomena. This control and was obtained by developing systems and processes of micro and nano fabrication for the realization of devices (also referred to as lab-on-chip) capable of exchanging signals (detection and implementation) systems with the size of few nanometers coining, in fact The definition of nanotechnology.
The course will discuss the process of miniaturization of the devices and the how the scale reduction can change or generate many (new) phenomena that distinguish the operation of nanodevices. We will present the main technologies for nanofabrication and we will show examples of application for the construction of devices and experiments at nanoscience. After a general distinction between processes top-down and bottom-up, we will explained the technology of lithography (UV, electronic, X-ray, ion imprinting, interference etc.), the processes of deposition (plasma assisted, or chemical vapor phase, sol-gel, etc.) and etching in the gas (reactive ion etching, milling) or liquid (chemical etching) phase. We will review manufacturing technology of electronic devices based on silicon.
The course is orinted to students in view of their thesis also looking at the broad correlation between physical, chemical, bio-chemical phenomena involved in the creation of
nanostructures and nanodevices. The course covers issues of industrial nanotechnology research.
The course is complemented by visits in nanofabrication laboratory in Trieste at the laboratories of the CNR nanofabrication at the synchrotron Elettra. During these visits they will have practical demonstrations of lithographic processes during the course in the classroom.
Syllabus: Nanofabrication:
Program
Nanofabrication: general concepts
Types of lithographs: Top down and bottom-up
Mask - maskless lithography parallel serial
Types of processes sottrattivi
Process development
The role of nanofabrication in production processes
The methodological approach of nanofabrication: interdisciplinary thematic.
Lithographs and Device Types
Diffractive optics,
Microfluidics,
Electronic devices, lab-on-chip, etc.
Lithographs 2D and 3D
Resolutions vs. throughput
Lithographs tridimensioni
Combinations of lithographs
FIB (Focused ion beam)
Resist less
Mask less lithography
First type of lithography
Resist
Introduction to resist: ownership 'and lithographic process
types of resist
Processes on the resist
Spinning
Baking
Dose and development
Contrast, resolution,
Litographic sensibility
Photochemical Quantum efficiency
Plasma etching resistance
Electron beam lithography
Electron sources
Vector scan
Beam blanking
Interaction with electron beam
Energy dependence
Proximity effects - dose correlation
Resolution limit
Exposure time
Stitching
Overlay
Single LEVEL- multi levels
Examples
Generality of lithographic techniques parallel
Replica of pattern
Masks
Molds
UV lithography
UV lithography proximity
UV lithography far field
Optical lithography
General principles
Diffraction
Interference Lithography
Principle of 'interference
Mode'
Property
X-ray lithography
LTX proximity
X-ray lithography far field
Deep X-ray
Next generation Deep EUV
Alignment and exposure
Several step processes
Nanoimprinting

**Examination:** Oral exam, presentation of the work and assessment of the main concepts of nano lithography. A depth study of a topic will presented after a written report preparation.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SC1174/2015/000ZZ/1133875

86. **Optics of materials**
Master degree in **Materials Science**, First semester
Lecturer: Moreno Meneghetti
Credits: 6 ECTS

**Prerequisites:**
Basic knowledge of electromagnetic wave propagation and of quantum mechanics.

**Short program:**

**Examination:** Oral.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SC1174/2015/000ZZ/1126579

87. **Organic Functional Materials**
Master degree in **Materials Science**, First semester
Lecturer: Michele Maggini
Credits: 6 ECTS

**Prerequisites:** Base Chemistry courses of the 3-years Laurea Degree

**Short program:**
Carbon nanostructures
• Fullerene functionalization
• Functionalization of carbon nanotubes and graphene

Semiconducting polymers
• Synthesis of semiconducting homo and copolymers
• Band gap engineering of semiconducting polymers
• Molecular structures for OLED emitting white or blue light
• Polymer solar cells

Examination: Oral.

88. Superconducting Materials
Master degree in Materials Science, Second semester
Lecturer: Vincenzo Palmieri
Credits: 6 ECTS
Prerequisites: Solid State Physics
Short program:
PRINCIPLES OF SUPERCONDUCTIVITY: Electrical conduction in metals; Phenomenology on superconducting materials; Two-Fluid model; London Electrodynamics; Superconducting Electrodynamics in Fourier Space; Type-II Superconductors; Thermodynamics of Superconducting Transition; Bose condensation; Microscopic Theory of Superconductivity; The Superconducting State; Quasiparticles Excitations; The Hydrodynamic approach to superconductivity.
SUPERCONDUCTING MATERIALS: Superconductivity on transition metals and Matthias' empirical rules; B1 and A15 compounds; High TC and magnesium diboride; Superconductivity Radio Frequency
INDUSTRIAL APPLICATIONS OF SUPERCONDUCTIVITY: Superconducting magnets, bearings and motors; Radiofrequency Cavities; Particles detectors.
Examination: Oral.

NATURAL SCIENCE
89. Environmental Impact assessment
Master degree in Natural Science, First semester
Lecturer: Massimo De Marchi
Credits: 6 ECTS
Prerequisites: Ecology and environmental law.
Short 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
- 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
- Accounting methods for environmental good and services: Contingent Evaluation, Cost/Benefits Analysis
The management of participation inside environmental assessment procedures.

**Examination:** Working group evaluation report plus oral examination.

**More information:**

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**Environmental Mineralogy**

Master degree in **Natural Science**, Second semester

Lecturer: Gilberto Artioli

Credits: 8 ECTS

**Prerequisites:**
Basic chemistry and chemical thermodynamics. Essentials of mineralogy and geology.

**Short program:**
Natural solid materials: basic concepts of mineralogy and crystal-chemistry.
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:
(1) Hazardous minerals in nature and in working places: asbestos, free silica. Environmental monitoring, assessment, mineral quantification, disposal.
(2) Microporous materials and inclusion compounds: clays, zeolites, clathrates, gas hydrates. Crystal structure, crystal chemistry, absorption properties, ionic exchange properties, catalysis. Their use in environmental, agricultural, and industrial applications.
(3) Mineral dust. Origin, characterization. Implications for the palaeoclimatic and environmental reconstructions of the investigations of mineral dust entrapped in polar ice and ocean sediments.
(5) Binders and cements. Their use in history and in present societies as building materials. Environmental applications in solidification and inertization processes of wastes and polluted soils.
(6) Rare Earth Elements. REE cycle and natural resources. Their role in technological products, recovery from e-waste

**Examination:** (1) mid-term presentation on an analytical technique selected by the teacher. The student will summarize: (a) the fundamentals of the technique, (b) the instrumental configuration, (c) the resulting information, (d) describe one application with environmental implications.
(2) The student will deliver a final presentation on a topic with environmental implications agreed with the teacher. The student will present: (a) the scientific problem, (b) the data available in the literature, with critical discussion, (c) the prospected actions for a better definition or solution of the problem.

**More information:**

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**STATISTICAL SCIENCES**

**Advanced Mathematics for Statistics**

Master degree in **Statistical Sciences**, First Semester

Lecturer: Federica Giummolè

Credits: 9 ECTS
Prerequisites:
Sequences of real numbers: limit of a sequence, Cauchy sequences, subsequences. Series of real numbers: convergence and convergence criteria. Differential and Integral Calculus in R and in R^n.

Short program:
Functional Analysis (3CFU)
- Functions spaces Ck, Lp,W 1,p: definitions and basic properties. Hilbert spaces: definitions and basic results. The space L2.

Probability Theory (6CFU)
- Probability Distributions
- Conditioning
- Characteristic and moment generating functions
- Functions of random variables
- Normal distribution theory
- Convergence of Random Variables
- Central Limit Theorem
- Further topics
- Discrete time Markov chains
- Continuous time Markov chains
- Poisson process and Brownian motion

Examination: Written exam.

More information:
http://en.didattica.unipd.it/offerta/2016/SC/SS1736/2014/000ZZ/1150738

92. Computational finance
Master degree in Statistical Sciences, First Semester
Lecturer: Massimiliano Caporin
Credits: 9 ECTS
Prerequisites:

Short program:
Introduction (minor module)
- Introduction to financial instruments and markets;
- Investment choices under uncertainty and the approach of Markowitz;
- Market equilibrium, CAPM and APT, and market efficiency.
Main module:
1. The formalization of computational problems into a statistical package
2. Asset Allocation: from the approach of Markowitz to Risk Budgeting
3. Backtesting and performance evaluation
4. Introduction to Market Risk Management
The program might be subject to changes depending on a number of elements including: the interest of the students and their ability to solve computational problems with the statistical software; the occurrence of particular events in the financial markets. Changes to the program content will affect the list of tasks included in the team work.
**Examination**: The exam will be given in the form of a group homework. Each group (a team), will receive, at a beginning of the course (groups will be formed within the first two weeks of lectures), a list of tasks pointing at computational finance questions. The tasks list will be iterated during the course. Each team will have to coordinate activities, inducing team members to interact. During the exam session, each team will show results in the form of a presentation (PowerPoint-like). Each team member must have full knowledge of the presentation and of the analyses performed by the team and of the main findings.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SS1736/2014/000ZZ/1150745

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93. **Data Analysis**

Master degree in **Statistical Sciences**, First Semester

Lecturer: Monica Chiogna

Credits: 9 ECTS

**Prerequisites:**

Basic Mathematics (undergraduate level). It would be advantageous to have some background knowledge of elementary Probability Theory.

**Short program:**

Part 1: Statistical Methods (6CFU)
- Visualization: plots including histograms, box plots, scatterplots, scatterplot matrices, etc.
- Summary statistics and goodness-of-fit tests. One- and two-sample examples, t and F distributions.
- Concepts of simulation: simple simulation experiments.
- Linear regression, including multiple linear regression. Associated inference problems.
- Regression diagnostics. Classical approaches to ANOVA. Model selection.
- Logistic regression and Poisson regression.
- Introduction to the design of experiments, observational studies and sampling methods.

Part 2: Applied Multivariate Techniques (3CFU)
- Dimension reduction
- Classification
- Clustering

**Examination**: Written exam, comprehensive of both parts of the course.

**More information:**
http://en.didattica.unipd.it/offerta/2016/SC/SS1736/2014/000ZZ/1150746

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94. **Environmental impact and life cycle assessment**

Master degree in **Statistical Sciences**, First Semester

Lecturer: Luca Palmeri

Credits: 6 ECTS

**Short program:**

The course is centred on the environmental impact assessment procedure. In particular the following topics are addressed: legislation (European and national), the administrative practice, the environmental impact study document writing and the tools for the evaluation of impacts. Several other closely related topics are discussed too: the strategic environmental evaluation, incidence evaluation and the integrated pollution prevention and control.

After an introduction to the general theory of decision making and of decision support systems, the principal evaluation tools are presented, e.g. multi-criteria analysis, risk analysis and life cycle assessment. Applications to real case studies are foreseen along the entire duration of the course in order to clarify the theoretical subjects presented.

**Examination**: Oral.

**More information:**
95. **Personal finance**

Master degree in **Statistical Sciences**, First Semester  
Lecturer: Guglielmo Weber  
Credits: 9 ECTS  

**Prerequisites:**  
Students should have taken a standard finance course, such as Teoria della Finanza/Computational Finance (from the graduate programme in "Scienze Statistiche").

**Short program:**  
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 portfolio diversification, as well as the consumption/saving choice. 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.

**Examination:** Written.

**More information:**  

96. **Statistical Models**

Master degree in **Statistical Sciences**, Second Semester  
Lecturer: Luisa Bisaglia  
Credits: 9 ECTS  

**Prerequisites**  
First year Unipd Masters of Statistics courses, especially Probability Theory and Advanced Statistics.

**Short program**  
Generalized linear mixed models  
- Introduction to the course: basic ideas  
- Generalized linear models: structure and inference  
- Extending GLMs: First instances of models for hierarchical data  
- Generalized linear mixed models  
- Introduction to hierarchical models and to GLMMs  
- Likelihood inference in GLMMs  
- Bayesian Hierarchical Models  
- Practical sessions with R and R-Bugs  
Time series analysis  
- Introduction. Linear time series models.  
- Linear time series models: model specification.
- Linear time series models: parameter estimation and forecasting.
- Introduction to spectral analysis
- Nonlinear models: an introduction
- Nonlinear models: Markov-Switching Models and Threshold Autoregression Models
- Long-memory models. Integer AutoRegressive models

Spatial statistics
1. Introduction to spatial statistics:
2. Estimation and modeling of spatial correlations:
3. Prediction and Interpolation (kriging):
4. Spatio-temporal modeling:
5. Second order spatial models for network data:
6. Gibbs-Markov random fields on networks:
7. Simulation and estimation of a Markov random field on a network:
8. Hierarchical spatial models and Bayesian statistics:

Examination: A written exam for each part of the course. Each exam will be marked independently by the corresponding instructor. At the end of the course, students will receive a final mark based on all 3 exams results.

More information:
http://en.didattica.unipd.it/offerta/2016/SC/SS1736/2014/000ZZ/1124383

97. Theory and methods of inference
Master degree in Statistical Sciences, Second Semester
Lecturer: Alessandra Salvan/Nicola Sartori
Credits: 9 ECTS

Prerequisites
First year Masters courses, especially Probability Theory and Advanced Statistics.

Short program
- Likelihood: observed and expected quantities. Exact properties and reparameterizations.
- Likelihood inference: first order asymptotics and computational aspects in R.
- Introduction to Bayesian inference.
- Estimating equations and pseudo-likelihoods.
- Data and model reductions.
- The frequency-decision paradigm.
- Exponential families.
- Exponential dispersion families and generalized linear models.
- Group families.

Examination: 1/3 homework. 1/3 final written exam, 1/3 written and oral presentation reviewing one or two recent research papers.

More information:
http://en.didattica.unipd.it/offerta/2016/SC/SS1736/2014/000ZZ/1150769
98. **Evolutionary Biology**

Degree in **Biology**, Second Semester

Lecturer: Andrea Augusto Pilastro, Mauro Agostino Zordan

Credits: 10 ECTS

The first part of the course is in Italian language, the second part (Population Genetics) is in English language, with the following characteristics:

Lecturer: Prof. Mauro A. Zordan

Credits: 5 CFU

**Prerequisites:**

Formal Genetics and basic Molecular Biology are fundamental prerequisites. Basic knowledge in Mathematics and Informatics would also be useful.

**Short program:**

The general theme of the course is the origin, maintenance and meaning of genetic variability. The study of population genetics provides the necessary tools for the comprehension of the genetic mechanisms which are the driving force of biological evolution.

1. Genetic variability in populations;
2. How is genetic variability organized?
3. The Hardy-Weinberg principle;
4. Recombination, linkage and linkage disequilibrium;
5. The structure of natural populations;
6. The origins of genetic variability;
7. Random genetic drift;
8. An introduction to coalescence theory;
9. Inbreeding and non-random breeding;
10. Population subdivision and genetic flow;
11. Darwinian selection;
12. The molecular basis of population genetics;

**Examination:** The final exam will be written, with multiple choice questions, short answers and problems involving the analysis and interpretation of mock experimental data.

**More information:**


99. **Physical- Mathematical Models**

Degree in **Mathematics**, First Semester

Lecturer: Franco Cardin

Credits: 6 ECTS

**Prerequisites:**

Calculus, elementary algebra and geometry, and a first course in Mathematical Physics.

**Short program:**

1. Kinematics of Continuous systems, spatial and material representation.
3. Cauchy tetrahedron theorem.
7. Hagen-Poiseuille flow, plane motion of Navier-Stokes fluids, Bernoulli Theorem.
12. Fourier series and applications.

Examination: Written.


100. **Advanced Optometry And Contactology**

Degree in **Optics and Optometry**, Second Semester
Lecturer: Marino Formenti
Credits: 6 ECTS

**Prerequisites:**
- Ophthalmic Optics.
- Visual Optics.
- Optometry I.
- Optometry II.

**Short program:**
- Behavioral Optometry
- Philosophy
  - The behavioral approach to vision care
  - The optometric visual analysis: classical vs behavioral visual exam
- Vision and Stress
  - Nearpoint visual demands
  - Autonomic visual response to stress agents
  - Organism Stress response
  - Stress response in the visual function
  - Symptoms and signs of visual stress
  - Development of refractive errors and visual dysfunctions in response to visual stress
- Optometric Evaluation of learning problems
  - Developing learning readiness
  - Learning related vision problems
  - Visuo-perceptual-motor optometric evaluation
  - Myopia Control
  - Refraction in worldwide pediatric population
  - Myopia and environment
  - Effect of urbanization
  - Concept and importance of peripheral refraction
  - Optic defocus theory and philosophy: central vs peripheral vision
  - Studies in laboratory animals
  - New concepts in ophthalmic and contact lenses designs for myopia control
- Spectacles lens design
Soft lenses: Aspheric, Multifocals
Rigid Gas Permeable: a dynamic application of the sagittal philosophy
Design
Spherical
Aspherical
Multifocal
Reverse Geometry
Toric
Orthokeratology
History of orthokeratology
Daily wear orthokeratology
Overnight orthokeratology
Orthokeratology design
Corneal changes
How it works
Guidelines and protocol
Examination: Written.
More information:
http://en.didattica.unipd.it/offerta/2016/SC/SC1168/2013/000ZZ/1118036

101. Astrophysics 2
Degree in Astronomy, Second Semester
Lecturer: Paola Marigo
Credits: 6 ECTS
Prerequisites:
Elements of plane trigonometry, derivatives, integrals, basic knowledge of physics relating to previous courses. Preparatory courses: Astronomy I (two years) and Astronomy II (model A, third year).
Short program:
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.
5. Nuclear reactions.
Overview, time/space derivatives, limiting cases. Boundary conditions and their effect on stellar structure. How to obtain solutions.

7. Simple stellar models.
Polytropic 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 centre 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, nucleosynthesis. 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.

Examination: Oral/written examination on all topics covered during the course.

More information: