Study programmes
in
Off-shore Engineering
at the University of Bologna
Add value to your M.Sc. Degree: accept the Off-Shore Challenge

The exploitation of off-shore resources will play a strategic role in the future of mankind. A sustainable valorization of renewable and conventional off-shore energy sources may give a relevant contribution to balance the overall energy demand. The exploitation of marine bioresources combined to the improvement of coastal infrastructure can be a key to the economic development. Improved off-shore technologies will be needed to realize such scenario.

A growing demand for the development and installation of innovative off-shore structures, systems and facilities as well as of coastal infrastructures is experienced. Specific technical problems arise when off-shore structures and plants need to be designed and installed, also concerning safety and environmental issues that arise when operating in the marine context.

The challenge for a sustainable exploitation of off-shore resources requires highly qualified professionals, prepared to operate in an international context, ready to cope with advanced design techniques and to tackle the improvement and optimization of off-shore operations in harsh environments.

The programs in Off-Shore Engineering offered by University of Bologna were built to meet these needs. Three different programs are offered as two-year Masters (second cycle degree – Laurea Magistrale) entirely taught in English and officially recognized under the “Bologna Process”. Each program offers to gain specific skills on off-shore engineering from a different perspective: chemical engineering, civil engineering and environmental engineering.

The programs were designed in the framework of an intense cooperation with companies active in the off-shore sector. The topics of the courses offered were specifically defined to meet both the requirements of a high-ranked engineering preparation and to answer the professional needs of the sector. Participation of professionals in lectures, internships and graduation thesis in companies are available to the students choosing this programs.
Add value to your M.Sc. Degree: accept the Off-Shore Challenge

The University of Bologna
The Ravenna Campus: a strong territorial vocation

Academic programmes addressing Off-Shore Engineering at the Department of Civil, Chemical, Environmental and Materials Engineering:

- Master of Science in Chemical and Process Engineering
- Master of Science in Civil Engineering
- Master of Science in Environmental Engineering

Syllabus: aims and contents of courses:

- Master of Science in Chemical and Process Engineering
- Master of Science in Civil Engineering
- Master of Science in Environmental Engineering
- Courses offered in Ravenna within the programmes in off-shore engineering

Admissions to the International Master’s programmes in Off-Shore Engineering

Companies and Institutions supporting the Off-Shore Engineering programme
The University of Bologna

The institution that we today call the University of Bologna was the first university in the western world, taking shape in Bologna at the end of the eleventh century.

In line with this strong tradition, the University of Bologna is now one of the most important and best reputed amongst Italian universities. Bologna is characterised by the largest Italian medieval historical city centre, and is very friendly to the 80,000 students that constitute the 16% of its population.

<table>
<thead>
<tr>
<th>The numbers of culture and innovation</th>
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<tbody>
<tr>
<td><strong>84,215</strong>: the students who have chosen the University of Bologna, making it the most popular university in Italy. Teaching and extra-curricular activities take place in 1,086,134.88 m² of space in the campuses of Bologna, Cesena, Forlì, Ravenna and Rimini.</td>
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<tr>
<td><strong>11,000</strong>: (average) number of research products, <strong>200</strong> patents, <strong>350</strong> funded research projects (VII framework programme and other EU programmes), <strong>7</strong> Inter-departmental Centres for Industrial research (CIRI), <strong>6</strong> national technological clusters of the Ministry of Education; University and Research.</td>
</tr>
<tr>
<td><strong>33</strong>: the Departments of the University of Bologna.</td>
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<td><strong>11</strong>: the Schools of the University of Bologna.</td>
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<tr>
<td><strong>9</strong>: the Research and Training Centre.</td>
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<td><strong>5</strong>: the Campuses of the University of Bologna.</td>
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<tr>
<td><strong>207</strong>: Degree Programmes: <strong>92</strong> first cycle 3-year programmes, <strong>103</strong> second cycle programmes and <strong>12</strong> single cycle programmes.</td>
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<tr>
<td><strong>52</strong>: International degree programmes, 27 of which are delivered in English.</td>
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<td><strong>48</strong>: PhD programmes, <strong>41</strong> specialisation schools, <strong>71</strong> first and second level professional master's programmes, 14 of which are international.</td>
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<tr>
<td><strong>2,288</strong>: international students from abroad on exchange programmes and <strong>2,381</strong> students</td>
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The Ravenna Campus: a strong territorial vocation

The first of its kind in the Italian university system, since 1989 the Alma Mater Studiorum has been structured as a **Multicampus**: the Bologna Campus works alongside the Campuses in Cesena, Forlì, Ravenna and Rimini. Every Campus has a **strong territorial vocation** with its own structures and services dedicated to learning activities, cultural and sporting events and associations. Every Campus has Schools, Departments and Local Organisational Units. Every Campus coordinates the services and initiatives supporting teaching and research, actively and organically liaising with **public and private stakeholders**, and therefore represents an essential driver of socio-economic growth in the territory it operates in. Topics of specialization were identified for each of the four Campuses in Romagna.

Ravenna, the natural seat for an Off-shore specialisation

Ravenna represents the **tradition and the history of oil and gas**. The Off-shore industry arose in Italy and in Ravenna from gas extraction in the Adriatic Sea, started by ENI in the second half of the 1950s. From then on, Ravenna has become one of the most important **global hub** for Off-shore companies, specialised in extraction plants construction and shipyards. Today, enterprises in the area of Ravenna are **international competitors working in the principal global markets**, such as North and West Africa, Mediterranean countries, North Sea countries, Latin America and Kazakhstan.

Since 1993, the **OMC Conference & Exhibition** takes place every two years. The OMC is the most important international event dedicated to the world of exploration and production of hydrocarbons on and Off-shore and technologies and related services in the Mediterranean. This is why Ravenna is the natural seat for a new degree in Off-shore. The best combination between **academic training** and **high-level professionalism** is achieved here. On one side there is the University, with its guarantee of excellence in the educational field, and on the other there are the local companies, expression of concrete experience in the sector.

The Off-shore curriculum is conducted in collaboration with **Fondazione Flaminia**, a body supporting the development of the Ravenna Campus and promoting synergies between institutions and companies since 1989.
Academic programmes addressing Off-Shore Engineering at the Department of
Civil, Chemical, Environmental and Materials Engineering

Three international study programmes addressing Off-Shore Engineering are offered by DICAM and the University of Bologna, with the support of companies in the Ravenna Off-Shore District and of Fondazione Flaminia.

The programmes, entirely delivered in English, address Off-Shore engineering from three different perspectives: design of off-shore processes for the exploitation of energy resources, design of off-shore structures and environmental issues in off-shore resource exploitation.

Within the Master of Science in Chemical and Process Engineering (Laurea Magistrale in Ingegneria Chimica e di Processo), the international curriculum in Sustainable Technologies for Energy and Materials (STEM) delves into the themes of Off-shore oil and gas technologies design, facilities for oil and gas production, and of Off-shore environmental and safety problems.

The International M.Sc. in Civil Engineering (Laurea Magistrale in Civil Engineering) delves into the themes of design, construction and management of Off-shore and maritime structures, starting from the action of the sea on constructions, and addressing fabrication techniques and structures assembling.

Within the Master of Science in Environmental Engineering (Laurea Magistrale in Ingegneria per l'Ambiente ed il Territorio), the international curriculum in Earth Resources Engineering (ERE) delves into the themes of Off-Shore resources management and exploitation, sustainability of Off-shore processes and impact of Off-shore structures on the environment.

The first year of the programme is delivered in the Bologna Campus. The second year is offered in the Ravenna Campus of University of Bologna.

Thanks to an agreement between Confindustria Ravenna and the University of Bologna, students attending the programme are offered the possibility to carry out an internship and to develop a Master’s Thesis in the companies operating in the fields of Off-shore engineering, safety and construction in Ravenna.

The collaboration with companies operating in the Ravenna area and with international research institutes has lead to a new field of specialisation on “Off-Shore Engineering”.

This programme is developed in the context of widely recognised and well-reputed Master’s of Science in Engineering: the University of Bologna is one of the best placed amongst Italian Universities in league tables and rankings.

The courses allow to plan an educational provision oriented to the training of new engineers in the Off-shore sector, with the enhancement of an extensive expertise in different sectors: chemical engineering, civil engineering, process design and operations, marine engineering, safety, and environmental engineering, construction and monitoring of Off-shore structures.
## Master of Science in Chemical and Process Engineering
(Second Cycle Degree/Two Years Master — Laurea Magistrale in Ingegneria Chimica e di Processo)
Sustainable Technologies and biotechnologies for Energy and Materials (STEM) Curriculum
- **Off-shore Engineering option**

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An internship can be carried out both as an “Elective” (6 ECTS) and as a Thesis’ project (Research A+B, 6+18 ECTS)
Master of Science in Civil Engineering  
(Second Cycle Degree/Two Years Master — Laurea Magistrale in Civil Engineering)  
Curriculum in Off-shore Engineering

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## Master of Science in Environmental Engineering

(Second Cycle Degree/Two Years Master — Laurea Magistrale in Ingegneria per l’Ambiente ed il Territorio)

### Earth Resources Engineering (ERE) Curriculum - Off-shore Engineering option

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An internship can be carried out both as an “Elective” (6 ECTS) and as a Thesis’ project (Research A+B, 6+18 ECTS)
FLUID MECHANICS AND TRANSPORT PHENOMENA M (9), ING-IND/24

Objectives: This course aims to provide students with advanced tools for analysing and modelling momentum, energy and mass transport in fluid or solid media. Continuum mechanics approach is used to address the discussion of fluid mechanics, heat and mass transfer problems. Successful learners in this course will be able to understand the role of local form of total mass, momentum, energy and species balance equations.

Course Contents: The course mainly addresses the continuum-level analyses of non-equilibrium processes in fluids (e.g., fluid flow under applied force, energy or mass transfer in flowing fluids). Continuum-level balance laws for mass, energy and momentum are derived. These provide the basis for the fluid mechanical and heat or mass transfer analyses in engineering. The need for material-specific “constitutive laws” for the “conductive” fluxes of mass, energy and momentum is demonstrated. These are developed from continuum and thermodynamic principles with reference to key experimental tests. Applications of the continuum theory are discussed to define important classes of problems, to demonstrate analytical methods, and to derive quantities usually sought in engineering analyses.

Specific topics:

The first law of thermodynamics, enthalpy, and heat capacity; energy balances with and without chemical reaction. The second laws of thermodynamics and its consequences on material properties: ideal gas and real fluid behavior for viscous fluids. Thermodynamic properties of solids, viscoelastic fluids; polymers and fluids with entropic elasticity. The second laws of thermodynamics and its consequences on process analysis:

MATERIALS CHEMISTRY M (6), CHIM/07

Objectives: This course is intended to provide (engineering students) with a good comprehension of the principles of chemistry and shows how they apply in describing the behaviour of the solid state. A relationship between electronic structure, chemical bonding, and crystal structure is developed.

Course Contents: The Materials Chemistry course addresses inorganic, organic and nano-based materials with a structure vs. properties approach, providing a suitable breadth of coverage of the rapidly evolving material fields. A few examples are: Advanced polymeric materials such as polymer matrix nanocomposites containing layered fillers (such as phyllosilicates and layered double hydroxides,) or carbon-based nanofillers like nanotubes, graphenes and fullerenes. From the application point of view, such novel materials may take on an increasingly important role in frontier research fields like solar energy harvesting in organic solar cells, and organic conductors in devices currently based on silicon semiconductors (like OLED, flexible displays, smart electrochromic windows). Nano-based materials will be introduced with a focus on the two different approaches to prepare them: top-down and bottom-up assembling of individual building blocks into more complex architectures. Solid state chemistry, with its traditional emphasis on crystalline structures featuring the most important archetypical unit cells, fundamental principles of X-ray diffraction and band model, still deserves some attention in this Materials Chemistry course, but it is paired with an amorphous-solids section to include up-to-date concepts in sol-gel synthesis techniques in the field of thin film preparation or surface modification.

Specific topics:

1) Amorphous and crystalline solids. Symmetry; the main symmetry elements. Lattices; unit cell; Bravais lattices. Miller indices for planes and lattice directions.


3) Bonding in solids. Ionic solids; the role of ion size; Shannon-Prewitt model for ions. Transition metal compounds and non-bonding electron effects. Crystal field theory. Band model for metals and semiconductors.

4) Crystal defects and non-stoichiometry. Role of point defects in diffusion in solids. Ionic conductivity. Some important solid state electrolytes for batteries and fuel cells.


6) LAYERED SOLIDS: layered double hydroxides, clays and their modification to improve the compatibility with polymers. Preparation of polymer nanocomposites using organoclay. Flame retardant properties of LDH and organoclay based polymer nanocomposites.
THERMODYNAMICS OF ENERGY AND MATERIALS M (6), ING-IND/24

Objectives: Knowledge about thermodynamic properties of fluids and materials and their use in phase equilibrium and reaction problems. Knowledge about the fundamentals of thermodynamic analysis for energy and process industry applications.

Course Contents: Thermodynamics governs energy transformations and the time evolution of the systems, requires precise constraints among the different state properties of matter and determines the final equilibrium states reached under proper external conditions. From a surprisingly small set of empirically based laws, an enormous amount of information about the relationships among equilibrium parameters for a system can be deduced. This information can then be applied to physical, chemical and biological systems including engine design, materials processing and cellular processes. Thermodynamics is a macroscopic theory, independent of any molecular model of matter, but molecular interpretations of various properties (e.g., entropy and temperature) will be discussed in the course to broaden intuitive understanding. The focus of this course is the further development of advanced thermodynamics. The objective of this course is to review the principles of thermodynamics and to apply them to advanced chemical engineering processes.

Specific topics:
NUMERICAL METHODS M (6), MAT/08

Objectives: A successful learner from this course will be able to: a) deal with numerical analysis topics such as: accuracy, truncation and round-off errors, condition numbers, convergence, stability, curve-fitting, interpolation, numerical differentiation and integration, numerical linear algebra; b) deal with numerical methods for solving ordinary and partial differential equations, with finite difference and finite element methods for parabolic and elliptic partial differential equations.

Course Contents: A successful learner from this course will be able to: a) deal with numerical analysis topics such as: accuracy, truncation and round-off errors, condition numbers, convergence, stability, curve-fitting, interpolation, numerical differentiation and integration, numerical linear algebra; b) deal with numerical methods for solving ordinary and partial differential equations, with finite difference and finite element methods for parabolic and elliptic partial differential equations.

Specific topics:

1) Key idea: accuracy, precision, truncation and round-off errors, condition numbers, operation counts, convergence and stability.

2) Numerical Linear Algebra: direct and iterative methods for linear systems.

3) Solution to single equations and multiple non-linear equations.

4) Interpolation and approximation: interpolating polynomials, cubic splines, least-square fitting.

5) Numerical differentiation and integration: Newton-Cotes quadrature formulas, Gaussian quadrature.

6) Classification of PDEs: elliptic, parabolic and hyperbolic equations.

7) Finite difference methods. Stability, consistency, and convergence theory.
INDUSTRIAL SAFETY M (6), ING-IND/25

Objectives: The course aims at providing the students with the basic elements of loss prevention and process safety in the chemical and process industry, including oil&gas up-stream and down-stream. Fundamental notions on substance hazards and classification of hazardous substances are provided. The approach to the process of risk assessment and management is described. The framework for risk control, governance and mitigation is also provided.

Course Contents: This course will provide students with knowledge of the theory and tools for loss prevention and risk analysis of industrial processes. The course will explore the safety implications of material and technology hazards. Students will be provided with the tools needed for the evaluation of the consequences and of the likelihood of accident scenarios, for risk analysis and for risk mitigation.

Specific topics:


INTRODUCTION TO BASIC DESIGN M (9), ING-IND/25

Objectives: The course aims at introducing the students to the design of unit operations. An introduction to basic design and process control is provided. Green engineering techniques, design for environment and innovative design techniques introducing sustainability and safety drivers in design will be presented. Design techniques will be applied to the more important unit operation in the chemical and process industry: heat transfer, distillation and absorption.

Course Contents: The aim of the course is to provide the students with a basic knowledge of the approach to the basic design of chemical processes. The procedures for the design of different categories of equipment items will be introduced, and constraints due to technological, safety and environmental issues in the context of process flow diagram definition will be discussed.

Specific topics:


3) Unit Operations: The concept of unit operations. Brief summary of the more common unit operations applied in the chemical and process industry.


5) Case-study: Design of a specific equipment item on the basis of the requirements coming from a process flow diagram and site utilities.
Courses offered in Bologna within the
1st year of the Master of Science in Civil Engineering
Curriculum in Off-shore Engineering

AIMS AND DETAILED CONTENT

Numerical Methods
**Geotechnical Engineering**

**Objectives:** The course is aimed at providing students with advanced knowledge of soil mechanics and geotechnical modelling, with special emphasis on their applications to the design of civil engineering structures. On successful completion of the course, the student will: know the characteristics and peculiarities of soil behaviour, be able to determine and compare physical and mechanical soil parameters, learn skills and develop methods for the design of main geotechnical structures.

**Course contents:** Previous basic knowledge of Soil Mechanics is required. Definition of the geotechnical model from laboratory and ground investigations. Standard and advanced laboratory tests; stress and strain analysis of the experimental data; Critical State Soil Mechanics. Planning and executing, in situ testing, result interpretation; site monitoring. Geotechnical characterisation; definition of the characteristic values of geotechnical parameters.

Design of geotechnical works. Stress paths; drained and undrained conditions; total and effective stress analyses; limit equilibrium methods; plasticity and limit analysis. Retaining walls: gravity and embedded retaining structures; criteria for design and stability analyses. Shallow foundations: bearing capacity and settlements; combined loading and stratified soil. Piled foundations: pile types and installation methods, design of single piles, load and integrity tests, lateral loads; pile groups and piled rafts. Slope stability: infinite slope and method of slices. Illustrative cases.

**Advanced Structural Mechanics**

**Objectives:** The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance the understanding of structural behavior and enhance the ability to apply classical structural analysis methods to civil engineering systems. The advanced methods for the analysis of structures will be applied to some structural examples which will be developed by the students.

**Course contents:**

I. Overview of classical methods for structural analysis.
II. Elastic analysis (linear). Structural matrix analysis (computer based simulations).
III. Plastic analysis. Limit analysis.
IV. Buckling analysis. Elastic stability, buckling loads.

**Advanced Design of Structures**

**Objectives:** Advanced methods for the verification and design of concrete structures will be given. The methods are based on the mechanics and simplified models for one- and two-dimensional concrete structures. A variety of civil engineering structures will be analysed. The advanced methods will be used to solve some real problems, with reference to European and US Codes and Guide Lines. The students will design some one- and two-dimensional structures under the supervision of the teacher.

**Course contents:** The course is divided into two teaching units: the first one, with 6 credits, is mainly focused on the designing of reinforced concrete structures while the second one refers to the design of steel structures and prestressed RC elements.

Part 1 (Prof. Mazzotti)
1. Design of RC frame structures
   Verification and design rules for RC sections under axial-bending loads according to the ultimate limit state method. Verification and design rules against shear and torsion. Provisions by European and American Guide Lines (Eurocodes and ACI).
2. Ductility of RC structures

3. Serviceability limit states of RC beams

4. RC plates subject to in-plane loadings

5. RC plates under transverse loads

6. Shell structures:

Part 2 (Prof. Silvestri)
GENERAL CONSIDERATIONS
- the design process and the role of the structural engineer
- the framework of the current technical codes (Italian codes and Eurocodes, USA specifications).
- basis of design: safety-checking formats (i.e. verification methods)
- materials

CONCEPTUAL DESIGN OF STRUCTURES
- loads path to the ground
- vertical-resisting systems
- horizontal-resisting systems (bracing systems, shear wall systems, pendular systems and moment-resisting frames).
- multi-storey steel building structures
- detailed analysis of a n-storey braced frame structure

DESIGN OF STEEL STRUCTURES
- serviceability limit states
- ultimate strengths (axial force, bending moment, shear, combined actions)
- buckling (axially loaded compression members, lateral-torsional buckling for beams, buckling for bending and axial force)
- brief notes about buckling of frames and second-order analysis methods
DESIGN OF COMPOSITE STRUCTURES
- idea
- composite beams (moment capacities, shear capacities, shear transfer and strength of shear connectors)
- composite columns

DESIGN OF PRESTRESSED CONCRETE STRUCTURES
- history, development and general principles of prestressed concrete structures
- prestressing systems
- determination of the internal forces
- traction (in order to understand the behaviour)
- flexure
- shear
- loss of prestress
- end anchorages and local verifications

Advanced Hydrosystems Engineering

Objectives: A successful learner from this course will be able to: a) deal with the most actual and urgent hydraulic and environmental problems connected with water supplies and drainage systems; design and operate urban water systems, taking into account: i) advanced design procedures and technological findings; ii) environmental and economic issues; and iii) construction site aspects; the b) apply basic modelling and computational techniques for addressing reliability analysis and risk assessment in civil engineering, with special emphasis on the water sector.

Course contents:
MODULE 1 - Water Supply Systems
General aspects of water supply systems: sources of potable water, networks layout and components.
Water distribution modeling
Water consumption modeling
Operations and control of water distribution systems
Water quality investigation and modeling
Energy management
Water losses monitoring and control
Design criteria for water supply systems
Optimization techniques applied to water supply systems
Water – energy nexus

MODULE 2 - Urban Drainage Systems
Overview of drainage systems
Planning of urban separate and combined drainage systems
Hydrologic cycle in urban areas
Estimating storm runoff and domestic sewage design discharges
Traditional and advanced design of urban drainage systems
Water quality issues in urban areas
Detention ponds and first flush tanks
Operation and maintenance of urban drainage systems

MODULE 3 - Uncertainty & Risk in Hydraulic Systems
Introduction. Syllabus. Objectives. Starting definitions on risk and uncertainty, also applied to hydrosystems. Introduction to risk analysis. Introductory concepts in
probability theory. Conditional probability.


**Infrastructure Systems**
Numerical Methods

Geotechnical Engineering

Objectives: The course is aimed at providing students with advanced knowledge of soil mechanics and geotechnical modelling, with special emphasis on their applications to the design of civil engineering structures. On successful completion of the course, the student will: know the characteristics and peculiarities of soil behaviour, be able to determine and compare physical and mechanical soil parameters, learn skills and develop methods for the design of main geotechnical structures.

Course contents: Previous basic knowledge of Soil Mechanics is required. Definition of the geotechnical model from laboratory and ground investigations. Standard and advanced laboratory tests; stress and strain analysis of the experimental data; Critical State Soil Mechanics. Planning and executing, in situ testing, result interpretation; site monitoring. Geotechnical characterisation; definition of the characteristic values of geotechnical parameters.

Design of geotechnical works. Stress paths; drained and undrained conditions; total and effective stress analyses; limit equilibrium methods; plasticity and limit analysis. Retaining walls: gravity and embedded retaining structures; criteria for design and stability analyses. Shallow foundations: bearing capacity and settlements; combined loading and stratified soil. Piled foundations: pile types and installation methods, design of single piles, load and integrity tests, lateral loads; pile groups and piled rafts. Slope stability: infinite slope and method of slices. Illustrative cases.
Engineering Geology

Objectives: Engineering Geology is aimed at studying the engineering and environmental problems which may arise as a result of the interaction between geology and human activities. The main goal of the course is to improve the knowledge of geological and geomorphological processes, developing skills in the analysis of their effects on civil engineering design.

Course contents: With reference to the aims of the course, the programme will deal with the topics listed hereafter.

a. Assessment of the geological model on the basis of the characteristics of soils and rocks and their mechanical behaviour; of a geognostic campaigns (boehole drilling, dynamic and static penetrometers etc.) and of monitoring data

b. Case studies of surveys and campaigns aimed at the assessment of the geological model of slopes.

c. Monitoring: devices and applications in different geological and geomorphological contexts.

Introduction to Numerical Methods

Objectives: A successful learner from this course will be able to: a) deal with numerical analysis topics such as: accuracy, truncation and round-off errors, condition numbers, convergence, stability, curve-fitting, interpolation, numerical differentiation and integration, numerical linear algebra; b) deal with numerical methods for solving ordinary and partial differential equations, with finite difference and finite element methods for parabolic and elliptic partial differential equations.

Course contents:

- Key idea: accuracy, precision, truncation and round-off errors, condition numbers, operation counts, convergence and stability.
- Numerical Linear Algebra: direct and iterative methods for linear systems.
- Solution to single equations and multiple non-linear equations.
- Interpolation and approximation: interpolating polynomials, cubic splines, least-square fitting.
- Numerical differentiation and integration: Newton-Cotes quadrature formulas, Gaussian quadrature.
- Classification of PDEs: elliptic, parabolic and hyperbolic equations.
- Finite difference methods. Stability, consistency, and convergence theory.

Laboratory of Environmental Engineering
Petroleum geosystems

Objectives: The Course is addressed to provide the basic knowledge of petroleum systems and petroleum engineering, with special reference to exploration, drilling and production engineering. These topics represent strategic elements as far as world energy supply is concerned. The Course is complemented with an introduction to the study of petroleum economics and the engineering phases of the petroleum industry, with applicative exercises and laboratory practices.

Course contents:

Part 1 (Prof. Paolo Macini)

Origin and geology of petroleum reservoirs. Fundamentals of petroleum economics; resources and reserves; production and consumption. Overview of Exploration & Production industry (Upstream). Oil and gas exploration techniques. Introduction to oil well drilling engineering.

Part 2 (Prof. Villiam Bortolotti)


Advanced Hydrosystems Engineering

Objectives: A successful learner from this course will be able to: a) deal with the most actual and urgent hydraulic and environmental problems connected with water supplies and drainage systems; design and operate urban water systems, taking into account: i) advanced design procedures and technological findings; ii) environmental and economic issues; and iii) construction site aspects; the b) apply basic modelling and computational techniques for addressing reliability analysis and risk assessment in civil engineering, with special emphasis on the water sector.

Course contents:

MODULE 1 - Water Supply Systems
General aspects of water supply systems: sources of potable water, networks layout and components.
Water distribution modeling
Water consumption modeling
Operations and control of water distribution systems
Water quality investigation and modeling
Energy management
Water losses monitoring and control
Design criteria for water supply systems
Optimization techniques applied to water supply systems
Water – energy nexus
MODULE 2 - Urban Drainage Systems
Overview of drainage systems
Planning of urban separate and combined drainage systems
Hydrologic cycle in urban areas
Estimating storm runoff and domestic sewage design discharges
Traditional and advanced design of urban drainage systems
Water quality issues in urban areas
Detention ponds and first flush tanks
Operation and maintenance of urban drainage systems

MODULE 3 - Uncertainty & Risk in Hydraulic Systems


BIOTECHNOLOGY FOR THE SUSTAINABLE RECLAMATION OF CONTAMINATED LANDS AND WATERS M

Objectives: To provide the students with the basics for understanding the roles of microbial populations in natural and contaminated habitats and with the main microbial and technological aspects related the conduction and optimization of the prominent environmental biotechnological processes currently applied in the remediation of industrial wastewaters, sediments and sites contaminated by xenobiotic compounds. Course contents: Chemical compounds released into the environment: their classification, source and fate as well as their environmental impact.

Course contents:
Main features, cellular organization and physiology of bacteria, fungi, algae and protozoa occurring in environments and/or applied in the environmental remediation processes. Biotransformation of biogenic compounds occurring/released in the environment. Anabolic and catabolic pathways. Catabolism of biogenic organic matter in aerobic and anaerobic habitats and processes. Aerobic respiration: the glycolysis, the Krebs cycle and the oxidative phosphorylation. Examples of environmental relevant microorganisms respiring aerobically biogenic organic compounds. Anaerobic metabolism of organic matter: nitrate-reduction, Fe(III)-reduction, sulphate-reduction, HCO3⁻ reduction (methanogenesis and acetogenesis) and main features of microorganisms using such anaerobic respiration routes. Fermentation of carbohydrates and proteins occurring in the environment and features of the main microorganisms responsible for it. Anaerobic digestion of organic matter and biowaste. Metabolism of inorganic compounds in aerobic habitats or treatment processes, such as nitrification, S²⁻ or S⁰ oxidation, Fe(II) oxidation and industrial microbial leaching and main features of microorganisms responsible for them. Introduction on the CO₂ autotrophic fixation and to the anoxygenic and oxygenic photosynthesis. Sources and fate of main organic and inorganic xenobiotic compounds in contaminated soils, sediments and waters. Microorganisms mainly involved in their biotransformation and detoxification and biochemical-molecular mechanisms responsible for their adaptation to the pollutants. Biodegradation pathways for aliphatic and aromatic hydrocarbons, chlorinated and not, in aerobic and anaerobic polluted environments. Basis of biotransformation on heavy metals in polluted sites. Contaminated sites: hydrogeology structure and fundamentals on contaminants transport and fate at the site (soil and groundwater). Approaches to the management of contaminated sites: containment and remediation. Main remediation technologies and types of ex-situ and in situ interventions. Basis and specific microbiological and technological aspects related to bioremediation ex-situ and in situ of sites contaminated by organic xenobiotic compounds. Basics of the Monitored Natural Attenuation (MNA) and Enhanced Natural Attenuation (ENA). Basics of myco-, phyt- and rhizo-remediation. Basics of physical-chemical remediation of soils under ex-situ conditions (soil flushing, soil washing, soil venting, chemical stabilization, incineration) and under in-situ conditions (thermal desorption and chemical stabilization). Physical-chemical remediation of contaminated groundwater under in-situconditions (air sparging and permeable reactive barriers). Basics on the main strategies for the (bio)remediation of contaminated sediments.
LABORATORY ON ALTERNATIVE AND RENEWABLE RAW MATERIALS M

Objectives: Provide fundamentals on the major waste streams and renewable and secondary feedstocks and on their current and potential industrial use as alternative resources to mitigate the current use of nonrenewable, primary raw materials.

Course contents:
Quantity and major features of most prominent waste streams and renewable feedstocks generated in Europe by the agro-food, forest and marine sectors, wastewater and municipal waste area
Biowaste: major features, sorting, storage and stabilization.
Biowaste biorefinery: concept, its exploitation in the sustainable production of biobased chemicals, materials and energy and its relevance in the frame of the European Biobased and Green economy
Production of Biobased fine chemicals, ingredients, materials and polymers from agrofood effluents and wastes and on the production of biofuels from municipal and agro-food industry effluents and wastes
Wastewater Biorefinery, Marine residue Biorefinery and Lignocellulosic residue biorefinery: basics and applications.
Mining waste: major features and novel exploitation pathways
Construction, ceramic and demolition wastes: major features and novel exploitation pathways
Non ferrous, steel and electronic waste: major features and novel exploitation pathways.

INDUSTRIAL ECOLOGY

Objectives:
- Knowledge about environmental impacts from industrial activities and their evaluation
- Knowledge about the evolution of the environmental policy in EU
- Knowledge about DPSIR model for the analysis and control of pollution process
- Knowledge about pollution control in conventional and alternative energy production

Course contents:
Sustainable Development: basic elements and open questions
The environmental policy of the European Union
Voluntary programs: Environmental Management Systems (EMAS/ISO14001);
Environmental Labels (Ecolabel/EPD)
Permitting procedures: Environmental Impact Assessment; Strategic Environmental Assessment; Industrial Emission Directive
Environmental protection through product policies: Integrated Product Policies; Design for the Environment; Extended Product Responsibility
The main environmental concerns from industrial activities
Resource use and sustainability conditions
Global warming: a phenomenological approach
Action to reduce anthropic emissions of green-house gases
Ozone depletion: a phenomenological approach
Photochemical smog: phenomenology and reduction strategies
Estimation of fugitive emissions from process plants
Energy production and the environment: connections, impacts, alternative energy sources
Greening the energy production: supply chain and life-cycle approaches
Raw materials for energy production by thermo-chemical processes: fossil fuels, alternative fuels, waste derived fuels and biomasses.
Thermo-chemical processes for energy production: combustion and pollutant formation
Plant technologies for energy production: combustion plants, pyrolysis and gasification plants.
Emission control and pollution prevention: inherent, pre-treatment and end-of-pipe strategies.

The life-cycle approach: perspective, application and limits
The LCA methodology (ISO14040 family)
Environmental indexes and indicators
Intensification and integration of processes; industrial symbiosis.
Bioremediation and exploitation of marine bioresources

Aim:
The course will provide students with the knowledge of biochemistry, microbiology and bioprocessing required for the sustainable remediation of impacted marine ecosystems (surface and subsurface water and sediments) and the industrial exploitation of marine biodiversity and bioresources.

Content:
Biodiversity of the marine microorganisms: Cellular organization, physiology, nutritional requirements and main features of marine bacteria, fungi and algae. Microbial metabolisms in the marine environment: photosynthesis; aerobic respiration, anaerobic respiration (nitrate-reduction, Fe(III)-reduction, sulfate-reduction, acetogenesis, methanogenensis), and fermentation of organic compounds; oxidation of inorganic compounds such as ammonium, sulfur, sulfide, iron(II). Microbial ecology of the marine (extreme) environment(s) and its monitoring.

Exploitation of marine bioresources: Bioactive compounds for pharmaceutical, nutraceutical, cosmetic, agrochemical applications from marine bacteria, fungi, micro- and macroalgae and cyanobacteria; functional food ingredients from marine microbes, macroalgae and fish; pigments and colorants for the food and cosmetic industry from marine filamentous fungi; new enzymes from marine extremophiles; the integrated production of chemicals, materials and fuels (biorefinery) from marine biomass and fish processing byproducts and waste; Biofuels from the exploitation of marine (micro)algae (biodiesel, algal biomass for combustion; biogas via anaerobic digestion of the biomass; biohydrogen; bioethanol via fermentation of carbohydrates derived from algae). Marine biofouling and ecofriendly biofouling prevention strategies based on marine microorganisms.

**Coastal Engineering**

**Aim:**
The course aims to provide tools and skills for the design and management of coastal and ocean structures, as well as the assessment of their impact. The course will introduce and describe the processes that characterize the oceanic and coastal environment and will provide tools for the analysis and design of coastal defenses, offshore structures, offshore and onshore approach facilities, and renewal energy plants.

**Content:**

**Corrosion and Protection of Metallic Structures**
6 ECTS, ING-IND/22

**Aim**
The aim of the course is to introduce the student to the metallic materials used for offshore installations and equipment. Knowledge on construction technologies, corrosion protection and materials for the protection from fire will also be provided.

**Content**
Thermal, chemical, mechanical treatments of metal surfaces and protection methods: high-temperature resistant materials. Choice criteria definition for metals suitable for marine environment and off-shore structures.

**Design of offshore structures and foundations**

**Aim:**
The aim of the course is to provide for the basic and some advanced elements for design of offshore structures. After an extensive illustration of requirements and protocols for certification of steel for construction, the elements of design of steel structures will be given, including strength requirements, instability verification, design of connections (bolted and welded), with particular emphasis to those typical of off shore structures. Design criteria on more complex steel elements (tanks, pipes, plates, shell, etc.) will be also given. Criteria for life extension of existing off shore platforms will be also given. Then, typologies of foundations for off shore structures will be illustrated, together with the design criteria for different soil and loading conditions.

**Content:**
Introduction to structural design for offshore structures: Overview on the main design codes (ISO, API, Norsok); Materials: steel for offshore structures, concrete. Limit state design fundamentals. Loads.
Design of fixed steel structures: Strength requirements; Stability of structural members; Bolted connections; Welded connections.
Seismic design of fixed steel structures: Seismic hazard and design spectra; Ductility requirements and seismic design.
Life extension of existing platforms: Fatigue analysis; Stress ranges and hot-spots; Residual fatigue life.
Design of steel plates and shells: Flexural behaviour of plates; Flexural behaviour of circular cylinders; Design criteria for plates and shells.
Overview of main anchoring systems: Overview of anchor types: surface gravity anchors, anchor piles, suction caissons anchors and drag anchors. Basis of design of main anchoring systems.
Exploitation of Off-Shore Oil & Gas Resources (ERE)

Aim:
The aim of the course is to introduce the student to the processes and technologies for the exploitation of off-shore Oil & Gas resources. The student will gain knowledge on the exploitation principles of off-shore reservoirs.

Content:
Exploitation of Off-Shore Oil & Gas Resources (STEM)

Aim:
The aim of the course is to introduce the student to the processes and technologies for the exploitation of off-shore Oil & Gas resources. The student will gain knowledge on the exploitation principles of off-shore reservoirs and on sub-sea, top-side and floating production technologies.

Content:

Hydrocarbon reservoirs: conditions for the existence of an oil or gas reservoirs, sedimentology, generation and migration of hydrocarbons; hydrocarbon traps. Temperature and pressure in petroleum systems. Physical properties of reservoir fluids: composition, phase behavior of hydrocarbons systems under reservoir conditions, thermodynamic properties of reservoir fluids. Reservoir distribution of petroleum fluids. Thermodynamic classification of hydrocarbon reservoirs.


Part II: Production. Introduction to Oil & Gas production technologies: structure of the petroleum industry, oil & gas production, main up-stream and mid-stream processes, relevant design standards and codes.

Topside upstream technologies: upstream gas processing, upstream oil processing, wellheads, separation, pumping, compression, gas treatments, auxiliary units, pipeline transportation, hydrate inhibition, water treatment.

Floating production systems: introduction to floating production technologies, system architecture, wellheads, flow-lines, separation, gas treatments, installation and anchoring. Subsea upstream technologies: introduction to subsea technologies, system architecture, wellheads, flow-lines, separation, pumping/compression, gas treatments, auxiliary units, sub-sea installation and maintenance.

LNG technologies for off-shore applications: the LNG chain, LNG transportation, types of LNG terminals, off shore LNG processing, offloading, storage tanks, vaporizers, quality correction, boil-off gas management.

Basis of design for off-shore technologies: heat exchange equipment, separation equipment, pumps/compressors, utilities.
Laboratory of off-shore Oil & Gas Exploitation

Aim:
At the end of the course the student has obtained knowledge on the exploitation principles of oil & gas reservoirs and on exploitation technologies.

Content:
Overview of the Oil & Gas industry and basics of petroleum economics. Evaluation of oil and gas reserves: definition and classification of reserves. Italian legislation concerning oil and gas leases; Italian energy department functions. Industrial phases and economic evaluation of oil and gas development projects. Environmental impact studies. Introduction to Oil & Gas exploitation technologies: structure of the petroleum industry, oil & gas production, main up-stream and mid-stream processes, relevant design standards and codes.

Modelling of offshore structures

Aim:
In the course, element for modelling of offshore structures will be given. Three main parts of the course will be: equivalent static and dynamic modelling of the actions, including wave action and wind, both in the time and frequency domains; finite element modelling of the structure, stress and displacement recovery and verifications; modelling and verifications against cyclic loadings, with special emphasis to fatigue and damage of metallic materials.

Content:
Introduction to structural solutions in the Offshore Environment: Platform typologies; Moorings; Pipelines. Environmental Actions on Offshore Structures: Buoyancy and gravity; Fluid-induced structural forces (waves, currents and winds); Earthquakes, ice impact and wave slamming; Deterministic and statistical descriptions of offshore waves. Dynamics of Offshore Structures: Deterministic responses for single degree of freedom structures in time and frequency domain; Statistical responses for single degree of freedom structures; Responses of multi-degree of freedom linear structures. Finite Element Modelling of a fixed-bottom platform: Members, joints and mass modelling; Actions modelling (permanent loads, wind, waves and currents, soil-structure interaction); Types of Analyses (static and quasi-static linear analysis, natural frequency, dynamically responding structures, non-linear analysis). Fatigue Assessment of Offshore Structures: Fatigue strength based on S-N curves; Damage accumulation rule and fatigue safety checks; Deterministic, simplified and spectral fatigue assessment methods; Stress concentration factor determination; Fracture mechanics approach.

Monitoring and Positioning in off-shore Engineering

Aim:
This course provides theoretical and operatives knowledges concerning the monitoring and positioning aspects in the offshore engineering. In particular, different techniques for an accurate positioning based on GNSS technology will introduced both for monitoring of
off-shore structures and for geolocalization of off-shore infrastructures. Examples of real applications regarding the monitoring or the positioning of offshore structures will be discussed.

**Content:**
Instrumentation and technologies for survey and positioning in off-shore engineering.
Classical Instrumentation and survey methods: Total Station and Spirit Levelling, application of the classical techniques in off-shore industry.
GNSS: GNSS observables (Pseudorange & Carrier phase), Impact of propagation Media (Troposphere, Ionosphere). Concepts on GPS carrier phase data Processing, Concepts on GNSS carrier phase within codes data processing (Precise point Positioning), Elements of Adjustment computation. Use of GNSS technique in off-shore Engineering.
Other sensors for subsea or subbed investigation: Elements of echo sounding for bathymetric surveys and Seismic.
Basic principles for sensors coupling.
Applications and examples in the field of Monitoring and Positioning in off-shore Engineering.

**Ocean and Coastal Engineering**

**Aim:**
The course aims to provide tools and skills for the design and management of coastal and ocean structures, as well as the assessment of their impact. The course will introduce and describe the processes that characterize the oceanic and coastal environment and will provide tools for the analysis and design of coastal defenses, offshore structures, offshore and onshore approach facilities, and renewal energy plants. In particular the student will be able to analyze the sea conditions (waves, currents) and to design coastal and ocean structures, as well as harbors, breakwaters, offshore structures (TLP, offshore). Particular attention will be dedicated to environmental impact assessment. The conversion of energy from the sea (waves and currents) will also be treated.

**Content:**
conversion. Environmental impact assessment of ocean structures. Case-study: preliminary design of a coastal and/or ocean structure. One or more visit to a company leader in offshore or marine engineering.

**Off-Shore Engineering and HSE management**

**Aim:**
The aim of the course is to introduce the student to the general themes of off-shore engineering and to provide specific knowledge on the Health, Environmental and Safety issues in off-shore operations, also focusing on those related to the production of Oil&Gas resources.

**Content:**
Introduction to the specificity of the off-shore context. Actions of waves and winds. Supply of critical services and utilities.
Health and occupational safety in off shore facilities: occupational safety issues, transportation risks, fatal accident rates, work organization and permit to work system, task analysis, safety culture. Periodic auditing and performance monitoring. Accident investigation.
Environmental protection in off shore facilities: evaluation of oil spill scenarios, environmental risk assessment.

**Off-Shore HSE Management**
6 CFU, ING-IND/25

**Aim:**
The aim of the course is to provide specific knowledge on the Health, Environmental and Safety issues in off-shore operations, also focusing on those related to the production of Oil&Gas resources.

**Content**
Health and occupational safety in off shore facilities: occupational safety issues, transportation risks, fatal accident rates, work organization and permit to work system, task analysis, safety culture. Periodic auditing and performance monitoring. Accident investigation.

Environmental protection in off shore facilities: evaluation of oil spill scenarios, environmental risk assessment.


**Technologies for off-shore Oil&Gas exploitation**

**Aim:**
The aim of the course is to introduce the student to the processes and technologies for the exploitation of off-shore Oil&Gas resources. The student will gain knowledge on sub-sea, top-side and floating production technologies.

**Content:**
Introduction to Oil&Gas exploitation technologies: structure of the petroleum industry, oil&gas production, main up-stream and mid-stream processes, relevant design standards and codes.

Topside upstream technologies: upstream gas processing, upstream oil processing, wellheads, separation, pumping, compression, gas treatments, auxiliary units, pipeline transportation, hydrate inhibition, water treatment.

Floating production systems: introduction to floating production technologies, system architecture, wellheads, flow-lines, separation, gas treatments, installation and anchoring.

Subsea upstream technologies: introduction to subsea technologies, system architecture, wellheads, flow-lines, separation, pumping/compression, gas treatments, auxiliary units, sub-sea installation and maintenance.

LNG technologies for off-shore applications: the LNG chain, LNG transportation, types of LNG terminals, off shore LNG processing, offloading, storage tanks, vaporizers, quality correction, boil-off gas management.

Basis of design for off-shore technologies: heat exchange equipment, separation equipment, pumps/compressors, utilities.
Turbomachines and power generation for off-shore applications

**Aim:**
The course is aimed at providing basic principles for design and operation of typical fluid machines used for “island” application in off-shore installations.

**Content:**
Admissions to the International Master's programmes in Off-Shore Engineering

In order to apply, students need to comply with the requirements set by the different Programme Boards, as specified in the Calls for applications.

For Chemical Engineering (Sustainable Technologies and biotechnologies for Energy and Materials – STEM):
http://corsi.unibo.it/2cycle/
ChemicalProcessEngineering-STEM/Pages/admission-procedure-INSERT

For Civil Engineering:
http://corsi.unibo.it/Civil-engineering/Pages/call-for-applications-INSERT

For Environmental Engineering (Earth Resources Engineering – ERE):
http://corsi.unibo.it/2cycle/
EnvironmentalEngineering-ERE/Pages/admission-INSERT

Pre-Applications possible in the period between January and June each year. Application and Enrollment in the period between September and December each year. Classes start in September each year. Fall Term lasts from September to December, Spring Term from February to May.

Completion of the Master programme entitles to access PhD studies.
Companies and Institutions supporting the Off-Shore Engineering programme