UNIVERSITY OF NAPLES FEDERICO II

DEPARTMENT OF STRUCTURES FOR ENGINEERING AND ARCHITECTURE

MASTER OF SCIENCE
IN

STRUCTURAL AND GEOTECHNICAL ENGINEERING

a) MASTER PROGRAM

The Master of Science in Structural and Geotechnical Engineering (**StreGa**) is a two-years Master of Engineering course offered by the Department of Structures for Engineering and Architecture of University of Naples Federico II (UNINA).

The program aims to train experts with special attention to topics such as earthquake engineering, innovative structural materials, retrofit and upgrading of existing constructions, innovative systems of structural control, new monitoring and diagnostic technologies, advanced technologies for foundation and excavation engineering, seismic geotechnical engineering, wind engineering and structural fire engineering.

The various range of skills acquired by the STREGA Graduates can find applications related to the following types of structures and infrastructures: residential buildings, industrial plants, road and rail infrastructure (bridges, viaducts, tunnels), hydraulic works (dams and reservoirs), great sport facilities, marine facilities both inshore and offshore, shallow and deep foundations, supporting structures, loose materials embankments, underground constructions.

The importance of guaranteeing safety for the structures of interest, in the light of the relevance and the complexity of the seismic actions, underlines the need for obtaining accurate risk estimates. Such risk estimates are going to be used for design, retrofit and maintenance programming of new and existing buildings.

This creates a comprehensive and complex setting for **StreGa** graduates, who as highly trained professional figures, are going to be provided with the necessary theoretical and scientific knowledge required for carrying on and managing complex design activities. They will be able to plan, design and supervise the various construction and retrofitting phases for buildings, industrial plants, bridges and other road/railway/infrastructures, water containment structures like dams and tanks, and coastal and off-shore structures.

The program is designed to create a multi-cultural educational environment that aims to provide the students with a rigorous technical basis and to boost their decision-making and leadership potentials. Students will have the opportunity to choose whether to specialize in a specific sector with high level of knowledge, or alternatively to acquire a broader range of skills with will provide them sufficient flexibility for confronting the challenges of the job market.

The main potential employers of **StreGa**'s graduates are national and multi-national construction companies, engineering and consulting firms, public authorities and research institutions. Last but not least, self-employment and running one's own company or office is another viable field of activity for **StreGa**'s graduates.

Examples of professional job opportunities and career paths for **StreGa**'s graduates are:

- Executive positions in governmental agencies and construction firms
- Designer positions for ordinary and special structures
- Designer positions for geotechnical works
- Risk analyst for insurance and reinsurance companies
- Catastrophe modeller for insurance and reinsurance companies
- Design of safety systems for industrial plants
- Design of interventions for the stability of the territory
- Rehabilitation design for the built environment
- Responsible for quality and safety-checking of critical facilities
- Consultant of public stakeholders for land-use planning
- Consultant for private and public bodies in general.

b) PROGRAM ORGANIZATION, ADMISSION REQUIREMENTS, FINAL EXAM, TUITION FEES AND SCHOLARSHIPS

All courses and activities are provided in English language; therefore, the program is open to students of any nationality with a certified knowledge of English language. The program duration is two years (four semesters) and corresponds to the acquisition of 120 ECTS (European Credit Transfer System). The first three semesters are dedicated to course-work, which consists of in-class teaching, practice, design and laboratory activities. During the fourth semester a final masters thesis is to be completed, usually in cooperation with Italian and foreign reasearch centers, industries, construction companies and design consulting firms.

For admission, a bachelor (3 or 4 years) degree in Civil/Architectural/Building/Enviromental Engineering released by a recognized Italian or foreign University is required. A committee appointed by the faculty council of **StreGa** decides about admissions and (if necessary) indicates specific pre-requisite courses needed to be completed before admission.

The final exam consists in the public defence of the master's thesis before a graduation committee. The final grade is obtained by combining the average scores obtained in all the courses attended during the master's program and the score of the final exam.
For Italian students, tuition fees are those normally required for the two-years Master of Engineering course offered by University of Naples Federico II; this is while for foreign students tuition fee waivers and scholarships are available.

More specifically, the tuition fees and taxes (accident insurance is included) are:

- € 140.00 for regional tax plus € 16.00 for stamp, for extra EU citizens;
- € 200.00 for registration fee, € 140.00 for regional tax plus € 16,00 for stamp (marca da bollo), for EU citizens.

For academic year 2020/2021, University of Naples Federico II offers scholarships for foreign students within the "Study of Naples" program. The call for application will be launched next January on official UNINA website. Moreover, every year, Italian Ministry of Foreign Affairs launches a call that offers scholarship to students from all around the world who want to study in Italy. The deadline for application is usually towards the end of May; therefore, interested students are invited to visit https://studyinitaly.esteri.it/en/call-for-procedure.

c) ACADEMIC CALENDAR

DEADLINE FOR APPLICATIONS	end of May
NOTIFICATION OF ADMISSION AND SCHOLARSHIP	end of July
REGISTRATION	end of October
FALL SEMESTER	end of Sept. - middle of Dec.
EXAM PERIOD	middle of Dec. - end of Feb.
SPRING SEMESTER	end of Feb. - middle of June
EXAM PERIOD	end of June - end of Sept.

d) MASTER COURSES

FIRST YEAR	**COURSE TITLE**	**ECTS**	**SSD**
FALL SEMESTER	Additional training requirements, if necessary (Table C)	18	ICAR/08 ICAR/09
	Earthquake engineering and structural control	9	ICAR/09
	Static and seismic foundation design	9	ICAR/07
SPRING SEMESTER	Limit analysis of structures	9	ICAR/08
	Advanced applied engineering mathematics	9	MAT/07
	Theory and design of steel constructions	9	ICAR/09
SECOND YEAR			
FALL SEMESTER	FEM in non-linear structural analysis	9	ICAR/08
	Design and retrofit of r.c. constructions	9	ICAR/09
	Mechanics of composite and advanced materials (*or alternatively*, Structural reliability - II semester)	9	ICAR/08 ICAR 09
SPRING SEMESTER	Advanced metallic structures	9	ICAR/09
	Innovative building materials	9	ICAR/09
	Tunnels and underground structures *or alternatively* Geotechnical modelling	9	ICAR/07
	Structural reliability (*or alternatively*, Mechanics of composite and advanced materials - I semester)	9	ICAR/09 ICAR 08
	Internship	9	
	Thesis dissertation	12	

Table C) Additional training requirements (if necessary, see par. “b” – Admission requirements)

Continuum mechanics - **FALL SEMESTER**	9	ICAR/08
Structural engineering - **FALL SEMESTER**	9	ICAR/09

CONTACTS:

Prof. Emidio Nigro, Coordinator of the Master Program (emidio.nigro@unina.it; ph. +39-081-7683686)

Dott.ssa Antonella Greco, Student Educational Office (antonella.greco@unina.it; ph. +39-081-7683335)

Dott.ssa Valeria Peluso, International Student Assistant (valeria.peluso@unina.it; ph. +09-0817683411)

WEBSITE: **www.strega.unina.it , www.dist.unina.it**

Course title: EARTHQUAKE ENGINEERING AND STRUCTURAL CONTROL	
Course module (if applicable):	
ECTS: 9	**SSD:** ICAR/09
Lectures (hrs): 50	**Tutorials (hrs):** 22
TWO-YEAR MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING - Year: I	
Course objectives: Scope of the course is to provide the required background knowledge of structural dynamics and basic methodologies for the design of engineered structures in seismic zones, as well as to conceive structural control systems able to reduce vibrations induced by other sources (wind, human and ambient born, traffic, industrial machines, etc.).	
Course contents: Dynamics of elastic SDOF systems: free vibrations, steady-state and generic forced vibrations, response spectrum representation of input action - Dynamics of elastic discrete MDOF systems: periods and vibration modes, modal analysis technique - Dynamics of continuum systems: one- dimensional shear and flexural beams, wave propagation in a three-dimensional body - Dynamic testing of structures: free and forced vibration tests - Inelastic dynamic response of structures: method of analysis, local and global ductility, energy balance Causes of earthquakes - Intensity and magnitude - Measurement instrumentation: seismometer, strong-motion accelerometer - Seismic waves – Amplification characteristics of surface waves and site response Behavior of constructions materials under dynamic loading: concrete, steel, other materials – Dynamic analysis of building structures: torsional vibration of space structures – Behavior of reinforced concrete structures: interaction between concrete and steel (bond, confining effect of transverse reinforcement, buckling of reinforcing bars), flexural and shear behavior of members, shear walls, beam-column connections, lateral load resisting systems - Behavior of steel structures: local buckling under monotonic and cyclic loading, behavior of beam and columns under monotonic and cyclic loading, connections, bracings – Outlines of behavior of composite, masonry and timber structures Earthquake resistant design: fundamental aseismic planning, static and dynamic analysis procedures, design earthquakes (response spectra and time histories), design of structural components (beams, columns, connections, shear walls, bracings, floor slabs) - Design of nonstructural elements, mechanical and electrical equipment - Aseismic design of foundations and retaining walls Dynamic structural control: classification (passive, active, semi-active an hybrid control), energy dissipation devices (viscous, visco-elastic, hysteretic and friction dampers), isolation and filtering devices, tuned mass dampers and tuned liquid dampers, semi-active (oleodynamic, electrorheological and magnethoreological) and active devices, design of structural control systems	
Instructor: GIORGIO SERINO	
Code: 30334	**Semester:** 1st
Required/expected prior knowledge: Tecnica delle Costruzioni I.	
Education method: The course is organized in theoretical lectures and practice sessions, during which numerous exercises and design problems will be considered and discussed. Every other week, a series homeworks will be assigned, to be completed within the subsequent two weeks.	
Textbooks and learning aids: The slides and the lecture notes are available on the instructor's web site (http://www.docenti.unina.it/giorgio.serino), together with the homeworks and midterm exams given in previous years. As textbooks, reference can be made to the followings: 1. A.K. CHOPRA, *Dynamics of structures: theory and applications to earthquake engineering*, Prentice Hall, 3rd edition, 2006. 2. Y. BOZORGNIA AND V.V. BERTERO, *Earthquake engineering: from engineering seismology to*	

performance-based design, CRC Press, Taylor and Francis Group, 2009. 3. M. WAKABAYASHI, *Design of earthquake resistant buildings*, McGraw-Hill, 1986. 4. L. NUNZIANTE, S. CHANDRASEKARAN, G. SERINO, F. CARANNANTE, *Seismic design aids for nonlinear analysis of reinforced concrete structures*, CRC Press, Taylor and Francis Group, 2009. 5. T.T. SOONG, M.C. CONSTANTINOU, *Passive and active structural vibration control in civil engineering*, Springer Verlag, 2002.
Assessment: midterm examination, whose grade will be considered in the final score; final oral exam only after having completed all the homeworks, which have to be brought solved at the exam.

Course title: FEM IN NONLINEAR STRUCTURAL ANALYSIS	
Course module: Theoretical lectures and practical training	
ECTS: 9	**SSD:** ICAR/08
Lectures (hrs): 50	**Tutorials (hrs): 30**
MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING - Year: I or II	
Course objectives: Aim of the course is to illustrate the theoretical aspects and the numerical techniques underlying the analysis, in the static and dynamic case, of structures exhibiting geometrical and mechanical nonlinearities.	
Course contents: Examples of the most frequent nonlinear behaviours in structural analysis. Geometrical and mechanical nonlinearities. Solution techniques of nonlinear problems: secant and tangent methods - Newton method and its variants. Line-search and arc-length. Examples of applications of such techniques to the ultimate limit state analysis of arbitrarily shaped reinforced concrete sections subject to axial force and biaxial bending. One-dimensional finite elements with mechanical nonlinearities: models with concentrated (plastic hinge) and distributed (fiber models) nonlinearities. Nonlinear analysis of framed structures and related solution techniques. Nonlinear static analysis (pushover) of framed structures. Comparison between limit analysis and ultimate limit analysis of framed structures. Numerical integration of the equations of motion of nonlinear structural systems. Dynamic analysis of frame structures subject to imposed accelerograms (time-history). Some examples of stability problems. Static and energetic approaches to the stability of elastic structures. Critical points of the equilibrium paths of a structural model: limit points of nonlinear models and bifurcation points (eulerian critical load). Sensitivity of structural problems to imperfections. Axial, flexural and torsion-flexural stability of beams. Stability of trusses and frames. The P-Delta method. Solution of stability problems by FEM.	
Instructor: LUCIANO ROSATI	
Code:	**Semester: I**
Required/expected prior knowledge: Scienza delle Costruzioni (Solid Mechanics)	
Education method: Lectures, Tutorials, Seminars	
Textbooks and learning aids: Lecture notes provided by the teacher.	
Assessment: Oral exam	

Course title: ADVANCED APPLIED ENGINEERING MATHEMATICS	
Course module	
ECTS: 9	**SSD:** MAT/07
LECTURES (hrs) 40	**TUTORIALS (hrs) 40**
MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING - Year: I	
Course objectives: After this course students should be able to: organize/develop mathematical model for the engineering problem at hand, solve partial differential equations using numerical methods, use finite-difference method and finite element method, use Matlab for scientific programming.	
Course contents: The main purpose of this course is the introduction to mathematical and numerical modeling for Engineering. The following topics will be discussed. Heat conduction and diffusion. Parabolic partial differential equations. Initial boundary value problems. Finite difference Method. Consistency, Convergence, Stability. Von Neumann criterion. Finite element method. Weak form. Dirac delta function. Elliptic partial differential equations and steady-state processes. Wave motions and hyperbolic partial differential equations. Euler-Bernoully equation and partial differential equations of higher order. Matlab for scientific programming	
Instructor: BERARDINO D'ACUNTO	
Code:	**Semester: 2**
Required/expected prior knowledge: Calculus, Mechanics	
Education method: Lectures, Tutorials	
Textbooks and learning aids: B. D'Acunto, Computational Partial Differential Equations For Engineering Science, Nova Publisher, New York.	
Assessment: Oral exam	

Course title: ADVANCED METALLIC STRUCTURES	
ECTS: 9	**SSD:** ICAR/09
LECTURES (hrs): 60	**TUTORIALS (hrs):** 20

MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING - Year: II

Course objectives:
The course main objective is to provide students with a deeper understanding of the behaviour, analysis and design of steel and aluminium structures. Students will be exposed to advanced analysis tools, considering non-linear material and geometric response of structures. They will learn the design principles and rules according to the Eurocodes. Finally, the course will provide students with knowledge and skills required for an international professional career.

Course contents: The Course is currently articulated into two parts. One part is dedicated to a general overview of steel structures all over the world; lectures for this part are given in the form of seminars by F. Mazzolani, expert of steel and aluminium structures, and Emeritus Professor at the University of Naples Federico II. The other part is more specifically addressed to provide students with design and analysis tools. More details about the course content are provided hereafter.
Seminars: The main features of structural steelwork; The big challenges of steelwork in buildings; The big challenges of steelwork in bridges; Steel buildings in urban habitats; Seismic upgrading of RC buildings; Passive control of new and existing buildings; Steel in structural restoration; Reticular space structures; Cold-formed thin-walled structures; Aluminium alloy structures.
Eurocode 3: Engineering aspects of the production process and mechanical properties of steel; Elastic and plastic resistance of cross sections; Classification of cross sections; Buckling of members; Second-order geometric effects, frame stability and global geometric imperfections; Buckling-restraining systems; Connections and joints.
Eurocode 8: Seismic design and analysis of traditional and innovative steel structures; Eccentrically braced frames; Buckling-restrained braced frames; Frames braced by shear panels.
Eurocode 9: Introduction to design and analysis of aluminium alloy structures.

Instructor: GAETANO DELLA CORTE

Code: 23388	**Semester:** II

Required/expected prior knowledge: Students are required to have basic knowledge of principles for design and analysis of steel structures.

Education method: Lectures on theoretical aspects will use both slides and blackboard; Tutorials and examples of calculation sheets will also be provided.

Texbooks and learning aids:
During the Course, copy of both lecture slides and calculation sheets will be provided. Readings of the following textbooks are suggested:

1. Luis. S. da Silva, Rui Simoes, Helena Gervasio, Design of steel structures, Eurocode 3: *Design of Steel Structures, Part 1-1 General rules and rules for buildings*, ECCS Eurocode design manuals, Ernst and Sohn.
2. *Steel designers' manual*, 7th Edition, SCI Steel Construction Institute, Buick Davison and Graham W. Owens (Editors), February 2012, Wiley-Blackwell.

Assessment:
Oral examination, with discussion of any eventual calculation example assigned during development of the course.

Course title: DESIGN AND RETROFIT OF RC CONSTRUCTIONS	
Course module (if applicable):	
CFU: 9	**SSD: ICAR/09**
Lectures (hrs): 54	**Tutorials (hrs): 26**
TWO-YEAR MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING – Year: II **LAUREA MAGISTRALE IN INGEGNERIA STRUTTURALE E GEOTECNICA – Anno di corso: II**	

Course objectives:
This course strives to provide an insight into the behavior of reinforced concrete (RC) buildings, focusing on the design of new buildings and the assessment and retrofit of existing ones, with particular emphasis on seismic action. To accomplish this task, the performance-based design and assessment of RC constructions are taught, starting from the definition of limit states and seismic action. One of the objectives of the course is to train specialized engineers who are familiar with linear and nonlinear methods of analysis of structures for seismic loads. Focusing on the design part, the program contains a detailed section analysis including flexure-axial interactions, design for shear, and the design of beam-column joints. In the second part of the course, the focus is on assessment of existing RC buildings by providing essential steps from safety-checking towards retrofit and retrofit design. The course has an application-oriented nature and the lectures are coupled with exercise sessions, that are mainly focused on a project on the design of a RC frame building, assigned to the students. One of the formative objectives of the course is learning to model RC buildings with software SAP2000.

Course contents:
General:
Definition of limit states, Seismic behavior of frames, load combinations for the ultimate and serviceability limit states, Calculating gravity loads, Calculating Seismic loads, q-factor, Ductility, Design vs retrofit procedure
Design of RC sections, elements and structures:
Concrete and reinforcing steel materials, Confinement, Section analysis under monotonic loading (combined flexure and axial load), Anchorage, Shear resistance of RC sections, Shear/flexure/axial interactions in RC sections, Beam-column joints
Assessment and Retrofit of RC constructions:
Assessment of existing buildings, Performance-based earthquake engineering. Knowledge levels, inspections and tests, Finite element modelling considering nonlinear behavior, Capacity models for shear strength and deformation capacity, retrofit strategies and techniques

Lecturer: HOSSEIN EBRAHIMIAN, PAOLO RICCI.	
Code: …	**Semester: 1st**
Required/expected prior knowledge: …	
Education method: Lectures, Exercises	

Textbooks and learning aids:
- Moehle, J., 2014. Seismic Design of Reinforced Concrete Buildings. McGraw Hill Professional.
- Fardis, M.N., 2009. Seismic design, assessment and retrofitting of concrete buildings: based on EN Eurocode 8 (Vol. 8). Springer Science & Business Media.
- E. Cosenza, G. Manfredi, M. Pecce. (2019) Strutture in cemento armato - Basi della progettazione. Hoepli.
- Norme Tecniche per le Costruzioni (NTC 2018). Supplemento ordinario alla Gazzetta Ufficiale, n. 35 del 11 Febbraio 2019. Ministero delle Infrastrutture e dei Trasporti, Circolare 21 Gennaio 2019 “Istruzioni per applicare dell'Aggiornamento delle Norme tecniche per le costruzioni» di cui al decreto ministeriale 17 Gennaio 2018” (in Italian).
- EN, Eurocode 8: Design of structures for earthquake resistance, 2005.
- ASCE/SEI Seismic Rehabilitation Standards Committee, 2017. Seismic evaluation and retrofit of existing buildings (ASCE/SEI 41-17). American Society of Civil Engineers, Reston, VA.
- FEMA. Techniques for seismic rehabilitation of existing buildings. FEMA-547, Federal Emergency

Management Agency, 2006.

- ACI Committee, American Concrete Institute and International Organization for Standardization, 2008. Building code requirements for structural concrete (ACI 318-08) and commentary. American Concrete Institute.

<table>
<tr><td colspan="2">Course title: STATIC AND SEISMIC FOUNDATION DESIGN</td></tr>
<tr><td colspan="2">Course module (if applicable):</td></tr>
<tr><td>CFU: 9</td><td>SSD: ICAR/07</td></tr>
<tr><td>Lectures (hrs): 56</td><td>Tutorials (hrs): 16</td></tr>
<tr><td colspan="2">TWO-YEAR MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING – Year: I LAUREA MAGISTRALE IN INGEGNERIA STRUTTURALE E GEOTECNICA – Anno di corso: I</td></tr>
<tr><td colspan="2">Course objectives: the course aims to provide the students with the knowledge needed to correctly design, monitor and reuse foundations under static and seismic loadings. Foundations always interact with both superstructures and subsoil and a safe and reliable design cannot neglect such interaction mechanisms. The study of theoretical aspects with their applications, calculations procedures and design methods to satisfy the needs imposed by static and seismic performance requirements and codes/regulations are the bases of the course.…</td></tr>
<tr><td colspan="2">Course contents: Introduction on foundation types: Deep and shallow foundations.
Definition of static and dynamic properties of soils relevant to foundation analysis and design. Overview on field and laboratory investigations for static and seismic characterization of the subsoil.
Shallow foundations: Types – Limit state design: ULS and SLS definitions – Bearing capacity and absolute and differential settlement – Plasticity theory applications to the bearing capacity problem (Upper bound and lower bound theorems) – Settlements calculations and time effects - Analysis and methods to solve superstructure-foundation-soil interaction – Allowable settlement and performance based design.
Pile foundations: Types and technology – Limit state design: ULS and SLS definitions – Static and dynamic load tests – Bearing capacity, settlement and stress for piled raft under vertical and horizontal loading – Conventional capacity based design and new trends in performance based design. Re-use of existing foundations: integrity checks and design

Dynamic soil-foundation-structure interaction: basic definitions; free-field ground motion; inertial and kinematic interaction; classification of the analysis methods.
Free-field motion: theory; empirical methods and significant case studies; dynamic analysis of seismic site response; simplified subsoil classification criteria; assessment of liquefaction potential with simplified and numerical methods.
Shallow foundations: pseudo-static analysis of bearing capacity; dynamic analysis of inertial interaction; impedance functions of footings; equivalent simple oscillator on compliant base. Case studies.
Deep foundations: pseudo-static analysis of bearing capacity; pseudo-static and dynamic analysis of kinematic and inertial interaction; filtering effect; impedance functions of piles; behavior of pile groups. Case studies.</td></tr>
<tr><td colspan="2">Lecturer: GIANPIERO RUSSO, FRANCESCO SILVESTRI</td></tr>
<tr><td>Code: …</td><td>Semester: 1st</td></tr>
<tr><td colspan="2">Required/expected prior knowledge: …Soil Mechanics</td></tr>
<tr><td colspan="2">Education method: …</td></tr>
<tr><td colspan="2">Textbooks and learning aids: Mandolini A., Russo G., Viggiani C. (2012). Piles & Pile Foundations Ed. Spon Press
Kramer S.L. (1996). Geotechnical earthquake engineering. Prentice-Hall, New Jersey.
Hsai-Yang Fang (1991). Foundation engineering handbook. Van Nostrand Reinhold.</td></tr>
<tr><td colspan="2">Assessment: oral test with discussion of the tutorials.</td></tr>
</table>

Course title: INNOVATIVE BUILDING MATERIALS	
CFU: 9	**SSD: ICAR/09**
Lectures (hrs): 50	**Tutorials: 20**
MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING - Year: I	
Course objectives: To provide fundamental knowledge and criteria for selection, design and verification of structural reinforced concrete and masonry members using innovative materials.	
Course contents: Innovative materials: high-performance concrete and fiber-reinforced concrete, high performance steel, fiber reinforced polymer (FRP) composites; mechanical properties; creep and shrinkage; structural safety, safety factors. Reinforced and prestressed concrete using innovative materials: flexure and axial loads, shear, bond, cracking and deflection; specifications and standards; structural applications. Reinforced concrete and masonry members upgraded with FRP laminates and FRCM materials. Criteria for the design of seismic upgrade of reinforced concrete and masonry structures. Design examples according to Italian Guidelines CNR DT 200.	
Instructors: ANDREA PROTA, CIRO DEL VECCHIO	
Exam Code: 20614	**Semester: I**
Requirements / Prerequisites: None	
Teaching Method: Lecturers, Examples, Tutorials, Discussion of Case studies	
Learning material: - Class notes. Course notes - Italian Guidelines CNR DT 200 (English version) - Model Code 2010 - fib bulletin 14 - ACI 440 guidelines on FRP materials for FRP reinforced concrete and for FRP strengthened concrete and masonry structures	
Final exam: Oral exam on course contents and on design examples carried out during the course.	

Course title: LIMIT ANALYSIS OF STRUCTURES	
ECTS: 9	**SSD:** ICAR/08
Lectures (hrs): 50	**Tutorials (hrs):** 30
Year: I	
Course objectives and overview: This course aims at providing students with a solid background on the theorems of Limit Analysis of structures and plasticity fundamentals of continuous bodies. Topics covered include: yield stress, plastic flow rules, materials stability, limit design of frames, plates and shells, structural collapse, variable loads in stable (shakedown) and unstable phase. A complete series of tutorials and applications in the static and kinematic Limit Analysis point of view are developed.	
Course contents: **Elastic-plastic material responses -** Laboratory tests on materials. Phenomenological models. The tensile test for steel and aluminium. Residual strain, Bauschinger effect. Tests in presence of multi-dimensional stress states until failure. Yield conditions for isotropic and non-isotropic materials: Tresca-Saint Venant, Henky-Von Mises, Hill, Schleicher, Mohr-Caquot, Mohr-Coulomb, Drucker-Prager, Tsai-Hill. **Foundations of plasticity Theory -** The Prandtl-Reuss flow rule. The Plastic potential. Associative and non-associative flow rules. Lévy-Von Mises and Tresca-Saint Venant associative flow rules. Elastic-perfectly plastic and elastic-hardening models. Isotropic and kinematic hardening. The Drucker's stability postulate and its consequences. The problem of elastic-plastic equilibrium. **Yield interaction axial force–bending moment** - Axial force-bending moment yield interaction. M-N plastic domains. Plastic flow and normality rule. Convexity of domain. The plastic hinge concept. **Plastic torsion -** The flux function for shear stress. The limit torque of beam sections. The sand cone analogy. E**lastic-plastic analysis of solids and structures until collapse –** Concept of plastic collapse. Step-by-step analysis of structures. General Theorems of Limit Analysis: static (safe or lower bound) theorem, kinematic (unsafe or upper bound) theorem for frame structures and three-dimensional Cauchy continua. Linearly increasing loads: static and kinematic bounds for the limit load multiplier (lower and upper bounds). Corollaries of Limit Analysis theorems (Feinberg theorems). Limit Analysis of beams assemblies and frames: uniqueness of collapse multiplier, multiplicity of failure mechanism. Collapse analysis with static theorem through a constrained optimization problem (usually linear programming), and kinematic theorem via the method of combined mechanisms. Collapse parametric analysis of frames. Limit Analysis examples for continuous elastic-plastic solids. **Plate and shells –** Introduction to limit response of plates and shells, applications of the static and kinematic theorem. **Shakedown of structures -** Beam structures under variable loads. The incremental collapse. The Colonnetti's principle. The shakedown static theorem (lower bound shakedown theorem - Bleich-Melan). The shakedown kinematic theorem (upper bound shakedown theorem - Koiter). Bleich-Melan approach as a mathematical programming procedure. Upper bound of displacement in elastic-plastic adaptation. **Computer codes:** Mathematica, Excel, Sap2000, Ansys.	
Instructor: **ANTONIO GESUALDO**	
Code: 26518	**Semester:** II
Requirements / Prerequisites: None	
Teaching method: Lectures, exercises and tutorials	
Learning material Class notes. Course notes. ***Basic reading*** Horne MR (1979) *Plastic theory of structures*. Pergamon Press. Neal BG (1977) *The Plastic Methods of Structural Analysis*. Chapman and Hall.	

Baker J, Heyman J (1980) *Plastic Design of Frames. 1 Fundamentals*. Cambridge University Press. Heyman J (2008) *Plastic Design of Frames. 2 Applications*. Cambridge University Press. Kachanov L M ((2004) Fundamentals of the Theory of Plasticity. Dover Publications. ***Further reading*** Yu M-H, Ma G-W, Li J-C (2009) *Structural Plasticity. Limit, Shakedown and Dynamic Plastic Analyses of Structures*. Springer. Hashiguchi K (2009) *Elastoplasticity Theory*. Springer. Lubliner J (2008) *Plasticity Theory*. Dover Publications. König JA (1987) *Shakedown of Elastic-Plastic Structures*. Elsevier Science Ltd.
Exam: final oral examination after completion of two assigned applications during the course.

Course title: MECHANICS OF COMPOSITE AND ADVANCED MATERIALS	
Course module: Theoretical lectures and practical training	
CFU: 9	**SSD: ICAR/08**
Lectures (hrs): 50	**Tutorials (hrs): 30**
TWO-YEAR MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING – Year: I or II **LAUREA MAGISTRALE IN INGEGNERIA STRUTTURALE E GEOTECNICA – Anno di corso: I or II**	
Course objectives: Composite and advanced materials are widely adopted in different field of Engineering and in the last decades there is great interest for these materials in Civil Engineering. Composites are obtained by assembling at least two different materials characterized by specific mechanical properties. The combination of different materials allows to get new materials with specific and interesting features. Advanced materials are characterized by extraordinary performances; Shape Memory Alloys are able to recover their initial configuration after a thermo-mechanical cycle, while Piezoelectric materials are able to convert the mechanical energy in electric energy and vice-versa, useful in many applications such as in the energy harvesting and structural monitoring. The aim of the course is to provide the capacity to model the mechanical response of the composite and advanced materials, allowing the possibility of predicting the behavior of new composites and, eventually, to tailor and design new materials, considering also their nonlinear behavior, including plasticity, visco-plasticity, damage, fracture.	
Course contents: Thermo-mechanics of materials: anisotropy, elastic and plastic deformation, creep and stress relaxation, thermo-elasticity, elements of damage, fracture and fatigue. Theory of Homogenization: concepts and definitions, analytical and numerical homogenization and localization techniques, derivation of overall properties and failure mechanisms in composites.	
Lecturer: ELIO SACCO	
Code: …	**Semester: 1st**
Required/expected prior knowledge: Statics, Elasticity, Strength of materials.	
Education method: Lectures with both slides and blackboard; Tutorials and examples of calculations; Seminars.	
Textbooks and learning aids : Nemat-Nasser and Hori, Micromechanics of heterogeneous media, North-Holland, 1999 R. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999 J. Aboudi, Mechanics of Composite Materials, Elsevier Science, 1991 Lecture notes distributed by the teacher	
Assessment: Oral examination.	

Course title: STRUCTURAL RELIABILITY

ECTS: 9	**SSD: ICAR/09**
Lectures (hrs): 54	**Tutorials: 27**

MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING - Year:II

Course objectives:

The course introduces alternative methods for the assessment of structural reliability. It begins by providing a brief overview of elementary concepts in probability, the history of the field of structural reliability and its evolution, and the general framework for structural reliability assessment. Next, the students are going to get to know classical methods for component reliability assessment such as FOSM, FORM, and SORM. Furthermore, classical methods for systemic reliability assessment are discussed. Simulation-based reliability methods are introduced next as an alternative to classical methods. The focus is on the use of standard Monte Carlo Simulation methods; however, notions of a few advanced and more efficient simulation routines are provided. Seismic performance-based structural safety assessment is a special focus of the course, and the students are going to learn how to evaluate structural risk and reliability due to seismic actions. In particular, they are going to evaluate the risk integral through introduction of intermediate variables such as seismic intensity measure (IM), engineering demand parameters (EDP), and damage measure (DM). Finally, Demand and Capacity Factor Design format for seismic safety-checking (DCFD) is introduced as an analytic closed-form solution to the risk integral.

Course contents:

Elementary Concepts in Structural Reliability and Safety

Brief overview of elementary probability and statistics, A brief history of the field of structural reliability and its evolution, General Framework for structural reliability assessment, Limit States, Failure Probability, Risk, Acceptable risk levels, Characterization of uncertainties

Classical Reliability Assessment Methods

Safety Margin and Safety Factor formulations for component reliability assessment, The Mean-Value First-Order Second-Moment method for reliability assessment (MVFOSM), The First-Order Second-Moment reliability (FOSM), Importance measures, Full distribution reliability methods, transformation into the standard Normal space, Nataf Distribution, First-Order Reliability Method (FORM), Second-Order Reliability Method (SORM), Systemic Reliability Assessment (systems in series and parallel, cut-sets, path-sets).

Simulation-based Reliability Assessment

Monte Carlo Method for structural reliability assessment, Importance Sampling, Markov-Chain Monte Carlo Simulation, Subset Simulation, The estimation of errors.

Performance-based seismic safety assessment

Introduction of seismic intensity measure (IM), engineering demand parameters (EDP), and damage measure (DM) as intermediate variables, Various risk metrics/decision variables (DV) (e.g., expected economic loss), The risk integral, Seismic fragility, Various types of fragility (EDP versus IM, DM versus EDP, and DM versus IM), Application of alternative non-linear structural analysis procedures (e.g., static pushover analysis, incremental dynamic analysis, multiple-stripe analysis, CLOUD analysis, etc.) in fragility assessment, Demand and Capacity Factor Design format for seismic safety-checking (DCFD).

Specific exercises: Application of alternative reliability assessment methods for safety-checking of a simple moment-resisting frame structure

Software: Brief applications in Matlab and Opensees

Instructor: FATEMEH JALAYER

Code:	**Semester:**

Required/expected prior knowledge: Nessuna

Education method: Lectures, Exercises

Texbooks and learning aids :

- R. E. Melchers. Structural reliability analysis and prediction, 2nd Ed., 2002, John Wiley.

- O. Ditlevsen, H. O. Madsen. Structural Reliability Methods, Internet Edition, 2007, John Wiley & Sons
- J. Benjamin, C.A. Cornell, Probability, Statistics, and Decision for Civil Engineers, Dover Books on Engineering, 2014
- Au, S.K. and Wang, Y., 2014. Engineering risk assessment with subset simulation. John Wiley & Sons.
- Jalayer F, Cornell CA. A technical framework for probability-based demand and capacity factor design (DCFD) seismic formats. Pacific Earthquake Engineering Center (PEER) 2003/08.
- FEMA-SAC Joint Venture. Recommended seismic design criteria for new steel moment-frame buildings. Federal Emergency Management Agency, 2000. FEMA-547, Federal Emergency Management Agency, 2006.
- FEMA 445-ATC-58: Next-Generation Performance-based Earthquake Engineering Design Criteria for Buildings: Program Plan for New and Existing Buildings, 2006.

Exam: Discussion of the project and an oral exam on course contents

Insegnamento: Theory and design of steel constructions	
Modulo /i:	
CFU: 9	**SSD: ICAR 09**
Ore di lezione: 72	**Ore di esercitazione:**
LAUREA MAGISTRALE IN INGEGNERIA STRUTTURALE E GEOTECNICA - Anno di corso: I o II	
Obiettivi formativi: 1. To introduce to students the theory and application of analysis and design of steel structures. 2. To prepare students to design steel structures against both gravity and seismic loadings. 3. To prepare students for the effective use of the standard formulas, tables, design aids and computer software in the design and analysis of steel members.	
Contenuti: This course aims to introduce the behaviour and design of steel structural members according to the limit states design concept under both gravity and seismic loading. The behaviour and design of tension members, compression members, laterally restrained and unrestrained beams, beam-columns and design of connections will be addressed. In addition, the seismic design principles and capacity design criteria for the main steel structural typologies will be covered. Students are expected to obtain basic knowledge about the design and failure mode of steel structural members after finished this course.	
Docente: Mario D'Aniello	
Codice: 30332	**Semestre: II**
Prerequisiti / Propedeuticità:	
Metodo didattico: Frontal lectures, seminars, tutoring	
Materiale didattico : **Slides of the course. In addition, the following documents are recommended:** – **EN 1993-1-1:2005 - Eurocode 3: Design of Steel Structures – Part 1-1: general rules and rules for buildings. CEN.** – **EN 1993-1-8:2005 - Eurocode 3: Design of Steel Structures – Part 1-8: design of joints. CEN.** – **EN 1998-1:2005. Eurocode 8: Design of structures for earthquake resistance. Part 1: General rules, seismic actions and rules for buildings. CEN.** – **Veljkovic M., Simões da Silva L., Simões R., Wald F., Jaspart J.-P., Weynand K., DubinaD.,** – **Landolfo R., Vila Real P., Gervásio H., "Eurocodes: Background & Applications. Design of Steel Buildings", Veljkovic M., Sousa M. L., Dimova S., Nikolova B., Poljanšek M., Pinto A. (Eds.), EUR 27346 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen, Luxembourg: Publications Office of the European Union, 2015** – **Landolfo, R. 2013. Assessment of EC8 provisions for seismic design of steel structures. Technical Committee 13—Seismic Design, No 131/2013. ECCS—European Convention for Constructional Steelwork.** – **Elghazouli, A.Y. 2010. Assessment of European seismic design procedures for steel framed structures, Bulletin of Earthquake Engineering, 8:65-89.** – **Mazzolani, F.M., and Piluso, V. 1996. Theory and Design of Seismic Resistant Steel Frames, E & FN Spon, an imprint of Chapman & Hall, London.** – **Ahmed Y. Elghazouli. 2009. Seismic Design of Buildings to Eurocode 8. Spon Press** – **Giulio Ballio, Federico M. Mazzolani. 1983.Theory and Design of Steel Structures. Taylor & Francis** – **Michel Bruneau , Chia-Ming Uang , Rafael Sabelli . 2011. Ductile Design of Steel Structures, 2nd Edition Hardcover . McGrawHill. ISBN-13: 978-0071623957**	
Modalità di esame: **Students have to carry out an individual project to practice on the seismic design and analysis of steel frames.** **Final Examination will cover the theoretical aspects described within the course and the discussion of the individual project**	

CFU: 9	**SSD: ICAR/07**
Lectures: 55	**Tutorials: 20**

MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING - Year: II	
Course objectives: Due to the increase of social demand for sustainable mobility in large urban areas, underground works involving tunnelling in densely urbanised areas increased in recent years. The aim of the course is to illustrate to the students the main geotechnical issues related to tunnelling and underground construction, particularly in urban areas. The fundamentals of tunnel design and the most common methodologies for tunnel construction are presented with the aid of documented case histories. Besides attending the theoretical lessons, students are involved in applied activities consisting in exercises reflecting the state-of-practice of geotechnical design of tunnels	
Course contents: **Geotechnical Investigation for Tunnel Construction.** Investigations at typical stages of a tunnel project. Rock rating and classification. Special tests for TBM excavation. **Tunnel Stability.** Limit analysis theorems. Stability of a plane strain circular opening in drained and undrained conditions. Stability of circular heading in drained and undrained conditions. Local stability. Stability of openings in rock mass. **Tunnel Construction Techniques.** Heading. Drill and blast excavation. Open face excavation. Tunnelling shields and Tunnel Boring Machines. Cut and cover tunnelling. Tunnelling waste and muck removal. **Stresses around Tunnels.** Stresses and deformation around an elastic cavity. Plane strain and axisymmetric conditions, supported and unsupported cavity in isotropic primary stress. Anisotropic primary stress. Anisotropic elastic ground. Circular cavity in elastoplastic ground. Ground and Support Reaction Lines. Stresses around tunnel heading. Stresses around a spherical cavity. **Principles of Tunnel Lining Design.** Arching. Ground-support interaction: continuum methods, bedded-spring models, convergence-confinement method. Examples of calculation methods. **Lining systems.** Sprayed Concrete Lining. Cast-in-situ concrete lining. Pre-cast segmental lining. **Ground Improvement Techniques.** Ground Reinforcement. Ground Freezing. Grouting. **Ground Movements.** Sources of ground movement around tunnel excavation. Empirical method of prediction. Analytical methods. Numerical methods: effects of soil non-linearity, anisotropy, small strain stiffness, and recent stress history. Influence of the building stiffness on the settlement profile, modification factors. Evaluation of relative stiffness parameters for masonry bearing walls, framed structures, façades with openings. Assessment of risk of damage to buildings. Protective measures: in-tunnel measures, ground treatment, compensation grouting, barriers. **Seismic Behaviour of Tunnels and Underground Structures.** Seismic behaviour and damage of cylindrical long underground structures (tunnels and pipelines): examples. Damage patterns and classification. Fragillity curves. Fundamentals of seismic site response analysis. Methods of analysis: transversal section, coupled and uncoupled approach; simplified methods; analysis in longitudinal direction. **Monitoring and control in Tunnel Construction.** Quality of measure. Types of instrumentations for tunnel construction. Observational method. Examples.	
Lecturer: EMILIO BILOTTA	
Exam Code: 32235	**Term: II**
Requirements / Prerequisites: None	
Teaching Method: Lectures, Classworks, Tutorials, Seminars on Case studies, Site visits.	
Learning material: - Lecture notes and slides - D.Kolymbas, Tunnelling and Tunnel Mechanics, Springer - D. Chapman et al., Introduction to Tunnel Construction, Spon Press	
Final exam: Oral exam on course contents and discussion on classworks	

Course title: GEOTECHNICAL MODELLING	
CFU: 9	SSD: ICAR/07
Lectures (hrs): 50	Tutorials (hrs): 30
TWO-YEAR MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING – YEAR: II	

Course objectives:
The course aims to provide students with theoretical and practical knowledge necessary for implementing numerical models for resolution of Geotechnical Engineering application problems. The course will deepen treatment of field equations for porous media and introduce constitutive relations used in geotechnical applications in a systematic way. The application of the finite element method to a series of Geotechnical Engineering problems is aimed at using the theoretical concepts acquired during the course.

Course content:
INTRODUCTION - The use of numerical models to solve Geotechnical Engineering application problems.
PART I - Field equations for a porous medium.
Undefined equilibrium equations (total stresses, effective stresses), congruence equations, constitutive relation, continuity equation, Darcy's law; particularities (drained, undrained conditions, coupled equations). Some simple applications: lithostatic stress state, indefinite slope, two-dimensional steady-state filtration, one-dimensional consolidation.
PART II - The Constitutive relationship.
Experimental evidence (stress path, isotropic compression, radial tests and dilatancy, oedometric tests; triaxial tests on loose and dense sands, strength criterion, critical state, strength criterion in the deviatoric plane; normal-consolidated clays and over-consolidated clays; drained and undrained triaxial tests on clays). Mathematical modelling (elastic models: linear, anisotropy, non-linear; general concepts of plasticity; Elastic-perfectly plastic models; Elastic-hardening plastic models).
PART III - Solution with the Finite Elements method of boundary value problems
The finite element method in the analysis of linear problems. Element technology Formulation of the EF method in saturated soil mechanics: drained and undrained conditions. The EF method for non-linear problems. Non-linearity in solids mechanics. Formulation of the EF method for non-linear problems (incremental approach). Numerical resolution of the incremental problem: explicit method and iterative methods. Elements of computational plasticity. Definition of initial conditions: the geostatic state. Definition of boundary conditions. The EF method for consolidation problems.
PART IV - Elementary applications.
Introduction to the use of finite element programs for geotechnical applications (Plaxis, Optum). Analysis of a shallow foundation (limit load, calculation of settlements and their time development). Construction of a road embankment (stability, subsidence). Stability of a slope (influence of groundwater level oscillations). Stability of an excavation (short-term conditions, long-term conditions, consolidation). Deep excavation protected by embedded-walls.
PART V - Development of a case study
Implementation of design codes within the calculation models. Modeling, analysis and verification of a case study used as the theme of the year

Teacher:

Code: …	**Semester: 2nd**

Required/expected prior knowledge: …

Education method: lessons, calculus exercises

Textbooks and learning aids: Slides of course; “Fondamenti di meccanica delle terre” R. Nova, McGraw-Hill; “Soil Mechanics” R. Nova John Wiley & Sons; “Geotechnical modelling”, D. Muir Wood, Spon Press; “Plasticity and Geotechnics” H.-S. Yu, Springer; “PLAXIS CONNECT EDITION V20 Manual” ed. Brinkgreve, Zampich, & Ragi Manoj, Plaxis bv.; “OPTUM G2:

Course title: STRUCTURAL ENGINEERING	
Course module (if applicable):	
ECTS: 9	**SSD:** ICAR/09
Lectures (hrs): 50	**Tutorials (hrs):** 26
MASTER DEGREE IN STRUCTURAL AND GEOTECHNICAL ENGINEERING - Year: I	

Course objectives: The scope of this course is to provide students with a solid background on the fundamentals of structural design (principles of structural design and reliability, calculation of sectional forces for typical frame structures, dimensioning of reinforced concrete and steel cross-sections and members, design and limit-state checks of simple structures). Theoretical lectures will be closely followed by sessions focused on practical applications of the material taught, which will be in the form of design examples.

Course contents:
Principles of structural safety and reliability behind modern design codes; partial safety factors for external actions and resistance in the structural Eurocodes. Serviceability and ultimate limit states. General properties of reinforced concrete and structural steel.

Calculating support reactions, sectional forces and deflections for simple linear-elastic structural systems and frames under static loading; beams on continuous elastic substrate (Winkler model); calculating normal and shear stresses according to beam theory; simple problems of elastic stability (Euler buckling).

Reinforced concrete; materials and conceptual design. Design of reinforced concrete sections under normal forces: uniaxial and biaxial flexure, flexure under compressive or tensile axial force; design of reinforced concrete members against shear and torsion; fundamentals of reinforcement detailing and conceptual design: beams, slabs, columns and footings; calculation of deflections in cracked state and verification of serviceability limit states.

Structural steel; Structural modelling for analysis and imperfections; Classification of cross sections; Resistance of cross-sections: tension, compression, bending moment, shear, torsion, combined actions; Buckling resistance of members: compression, bending, combined actions; Serviceability limit states for buildings; Connecting devices: bolted connections, welded connections; Structural joints; Composite floor slabs.

Instructors: LUIGI FIORINO, GEORGE BALTZOPOULOS	
Code:	**Semester:** 1st
Required/expected prior knowledge: Fundamentals of strength of materials	

Education method: The course is split between theoretical lectures and sessions that involve practical applications of the taught material. Students are expected to complete a course project that consists of designing two simple structures.

Textbooks and other learning material:
R.C. Hibbeler. Structural Analysis in SI Units, Global Edition. 2016. Pearson.
L.S. da Silva, R. Simoes, H. Gervasio. 2016. Design of steel structures. ECCS.
J.P. Jaspart, J.F. Demonceau, S. Renkin, M.L. Guillaume. 2009. European Recommendations for the Design of Simple Joints in Steel Structures. ECCS.
J.P. Jaspart, K. Weynand. 2016. Design of Joints in Steel and Composite Structures. ECCS.
R. Park, T. Pauley. Reinforced Concrete Structures. 1975, John Wiley & Sons.
D. Beckett, A. Alexandrou. Introduction to Eurocode 2: Design of concrete structures. 1997, CRC Press.
EN1993-1-1: Eurocode 3 - Design of steel structures - Part 1-1: General rules and rules for buildings.
EN1993-1-8: Eurocode 3 - Design of steel structures - Part 1-8: Design of joints.
EN1992-1-1: Eurocode 2 - Design of concrete structures - Part 1-1: General rules and rules for

Final assessment: Oral final exam; completed project will be evaluated during the exam.

Course title: CONTINUUM MECHANICS	
ECTS: 9	**SSD:** ICAR/08
Lectures: 50	**Tutorials:** 30
Year: I	
Course objective: Aim of the course is to illustrate the theoretical and practical aspects regarding the behaviour of deformable solids, relevant energetic principles and yield criteria. Emphasis is given to the case of elastic solids and beams and to the analytical and numerical methods for the analysis of plane structures composed of elastic beams. Particular attention is given to the practical application of the theoretical concepts presented within the course.	
Course contents: Introduction to vector and tensor algebra, index notation, introduction to vector calculus. Deformation analysis. Deformation of solids, strain and displacement gradients and their physical interpretation, volumetric strain, Green-Lagrange strain tensor, infinitesimal strain tensor and physical interpretation of its components, infinitesimal volumetric strain. Stress analysis. Cauchy stress tensor, equilibrium equations, symmetry of the stress tensor, principal stresses and principal directions, Mohr's circle, first and second Piola-Kirchhoff stress tensors. Constitutive equations. Elastic solids, Hooke's law, Young's modulus and Poisson's ratio, isotropic materials, elastic strain energy, Clapeyron theorem, Betti theorem, introduction to non-isotropic materials. Analysis of elastic structures. Equilibrium and resultants of forces and moments, distributed loads, statically determinate and indeterminate structures, equilibrium of statically determinate structures, lattice structures, internal forces in beams, Euler-Bernoulli and Timoshenko beam models, analysis of statically indeterminate structures, equilibrium and compatibility equations, force and displacement methods, principle of virtual works (force and displacement formulations), introduction to the finite element method. Stresses in beams. Axial load, pure bending, biaxial bending, geometric and elastic properties of a beam cross section, shear stresses in beams, Jourawski's formula for thin sections subjected to shear, torsion, circular beams subjected to torsion, first and second Bredt formulas, thin rectangular sections subjected to torsion. Yield criteria. Introduction to plasticity, Hambly's paradox, Tresca, Von Mises and Drucker-Prager yield criteria and their specialization to the case of beams, introduction to the plasticity static theorems. Stability of beams, Euler's formula for pin-ended columns and its extension to columns with other end conditions, eccentric loading, effects of imperfections.	
Code:	**Semester: I**
Instructor: FRANCESCO MARMO	
Required/expected prior knowledge:	
Education method: Lectures, Tutorials, Seminars	
Textbooks and other learning material: J. N. Reddy, An introduction to continuum mechanics, Springer. F. Irgens, Continuum Mechanics, Springer. F. P. Beer, E. R. Johnston, J. T. DeWolf, D. F. Mazurek, Mechanics of materials, Mc Graw Hill. Lecture notes.	
Final assessment: written exam	