



ALMA MATER STUDIORUM  
UNIVERSITÀ DI BOLOGNA

REGOLAMENTO DIDATTICO DEL CORSO

LM-23 [CIVIL ENGINEERING]

Sede di Bologna

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Qualora, unicamente a scopo di sintesi, nel presente regolamento sia usata la sola forma maschile, questa è da intendersi riferita in maniera inclusiva a tutte le persone che operano nell'ambito della comunità stessa.

### **Art. 1 Requisiti per l'accesso al corso**

#### *Conoscenze richieste per l'accesso*

Per essere ammessi al corso di laurea magistrale in Civil engineering, occorre essere in possesso di una laurea, di un diploma universitario di durata triennale, o di altro titolo di studio conseguito all'estero, riconosciuto idoneo.

Occorre, altresì, il possesso di uno dei seguenti requisiti curriculari:

#### *Requisito 1*

Avere conseguito un titolo di primo livello nella classe 8 (ex D.M. 509/99) o nella classe L-7 (ex D.M. 270/04) – Classe delle Lauree "Ingegneria Civile e Ambientale" - o nelle equivalenti classi degli ordinamenti previgenti.

#### *Requisito 2*

Avere conseguito la Laurea in classi diverse da quelle elencate nell'ambito del requisito 1 e avere acquisito un numero minimo di crediti formativi universitari nei gruppi di SSD elencati nel seguito (devono essere soddisfatti tutti e tre i sottopunti indicati a), b) e c)):

- a) Almeno 51 CFU nei Settori Scientifico Disciplinari ICAR/01, ICAR/02, ICAR/04, ICAR/05, ICAR/06, ICAR/07, ICAR/08, ICAR/09; ICAR/10, ICAR/11, ICAR/17;
- b) Almeno 39 CFU nei Settori Scientifico Disciplinari ICAR/01, ICAR/02, ICAR/04, ICAR/05, ICAR/06, ICAR/07, ICAR/08, ICAR/09;
- c) Almeno 24 CFU nei Settori Scientifico Disciplinari MAT e FIS.

#### *Requisito 3:*

Avere conseguito un titolo universitario all'estero giudicato idoneo da un'apposita commissione nominata dal Consiglio di Corso di Studio. L'idoneità viene stabilita in base ai criteri sopra elencati quando sia possibile l'individuazione di una classe di laurea equivalente secondo il sistema italiano, l'identificazione dei settori scientifico-disciplinari per gli insegnamenti e il numero di CFU conseguiti in ciascun settore. Se la conversione e/o l'identificazione non sono possibili, si procede alla valutazione della carriera da parte della commissione.

Per l'accesso al corso di studio è richiesta la conoscenza della lingua inglese di livello B2 del Quadro comune europeo di riferimento per la conoscenza delle lingue.

L'ammissione al corso di laurea magistrale è subordinata, inoltre, al superamento di una verifica dell'adeguatezza della personale preparazione che avverrà secondo le modalità definite nel punto Modalità di ammissione.

#### *Modalità di ammissione*

La verifica dell'adeguatezza della personale preparazione verrà effettuata da un'apposita Commissione nominata dal Consiglio di Corso di Studio. La Commissione valuterà il merito accademico, in primo luogo attraverso il voto di laurea del candidato che verrà considerato adeguato se non inferiore a 83/110. Per i candidati con titolo di studio non conseguito in Italia verrà operata un'opportuna conversione. La verifica della personale preparazione si ritiene assolta per i candidati non ancora in possesso della laurea qualora abbiano già acquisito 165 CFU ed abbiano una media dei voti ponderata sui crediti pari o superiore a 22/30.

Per gli studenti che non rispettano i requisiti sopra indicati, l'ammissione al corso di studio è subordinata alla specifica valutazione della carriera universitaria da parte della Commissione che valuterà il merito accademico in relazione agli obiettivi formativi del corso di laurea in Civil Engineering attraverso l'esame di altri elementi del curriculum accademico del candidato, quali:

- voti conseguiti nei singoli insegnamenti;
- durata degli studi in relazione alla durata nominale del corso di studi.

Per l'accesso al corso di studio è previsto l'accertamento delle conoscenze e competenze nella lingua inglese di livello B2 da dimostrare mediante certificazione linguistica secondo le modalità rese note tramite pubblicazione sul portale di Ateneo.

Nel caso di mancato superamento della verifica è preclusa l'iscrizione al corso.

**Art. 2 Regole di mobilità fra i curricula del Corso di Studio**

Il corso di studio è articolato in curricula.

Lo studente può effettuare le scelte indicate nel piano didattico, con le modalità indicate nel piano stesso e nei termini resi noti tramite il Portale di Ateneo.

È consentito il passaggio tra i curricula previsti entro i termini resi noti tramite il Portale di Ateneo.

**Art. 3 Piani di studio individuali**

È prevista la possibilità di presentazione di piani di studio individuali con le modalità, i criteri e i termini resi noti tramite il Portale di Ateneo.

I piani di studio individuali, approvati dal Consiglio di corso di studi, non possono comunque prescindere dal rispetto dell'ordinamento e delle linee guida definite dagli Organi competenti.

Qualora il piano di studio preveda la scelta di attività formative attivate presso corsi di studio a numero programmato, l'ammissione alle stesse deve essere previamente approvata anche dal Consiglio di corso di studio a numero programmato sulla base di criteri da questo preventivamente individuati.

**Art. 4 Modalità di svolgimento delle attività formative e tipologia delle attività didattiche**

Il piano didattico pubblicato indica tutte le attività didattiche previste, la suddivisione, le esercitazioni pratiche o tirocinio, nonché la tipologia di attività e i metodi didattici. Ogni ulteriore informazione sarà pubblicata con cadenza annuale sul sito del Corso di Studio.

**Art. 5 Percorso flessibile**

Lo studente può optare per il percorso flessibile che consente di completare il corso di studio in un tempo superiore o inferiore alla durata normale secondo le modalità definite nel Regolamento Didattico di Ateneo.

Le attività formative previste dal percorso di studio, in caso di necessaria disattivazione, potranno essere sostituite, per garantire la qualità e la sostenibilità dell'offerta didattica.

**Art. 6 Prove di verifica delle attività formative**

Il piano didattico allegato prevede i casi in cui le attività formative si concludono con un esame con votazione in trentesimi ovvero con un giudizio di idoneità.

Le modalità di svolgimento delle verifiche sono stabilite annualmente dal Consiglio di corso di studio in sede di presentazione della programmazione didattica e rese note agli studenti prima dell'inizio delle lezioni tramite il Portale di Ateneo.

**Art. 7 Attività formative a scelta dallo studente**

Lo studente può indicare come attività formative autonomamente scelte dallo studente due o più attività formative tra quelle che il Consiglio di Corso di studio individua annualmente e rende note tramite Portale di Ateneo. Se lo studente intende sostenere un esame relativo ad una attività non prevista tra quelle individuate dal Consiglio di Corso di studio, deve fare richiesta al Consiglio di Corso nei termini previsti annualmente e resi noti tramite pubblicazione sul Portale di Ateneo. Il Consiglio valuterà la coerenza della scelta con il percorso formativo dello studente.

**Art. 8 Criteri di riconoscimento dei crediti acquisiti in corsi di studio della stessa classe**

Questo articolo si applica esclusivamente a studenti provenienti da corsi di laurea magistrale (laurea di secondo ciclo) erogati in Italia a norma del D.M.270/2004, nella classe LM-23. Il riconoscimento dei crediti è deliberato dal Consiglio di Corso di Studio, che ne valuta la coerenza nell'ambito del piano didattico. Nel caso di provenienza da corsi di studio erogati in lingue diverse dall'italiano, il riconoscimento si riferisce ad attività didattiche svolte nelle lingue straniere indicate annualmente dal Consiglio di Corso di Studio.

**Art. 9 Criteri di riconoscimento dei crediti acquisiti in corsi di studio di diversa classe, in corsi di studio internazionali e in tutti i corsi di studio di università telematiche**

I crediti formativi universitari acquisiti possono essere riconosciuti dal Consiglio di Corso di Studio sulla base dei seguenti criteri:

- numero di CFU o equivalenti (es. ECTS) o, in mancanza di essi, numero di ore complessive;
- valutazione della coerenza dei settori scientifico disciplinari o, se questi non sono definiti, delle materie, e analisi del programma svolto, in relazione agli obiettivi formativi del Corso di Studio.

**Art. 10 Criteri di riconoscimento delle conoscenze e abilità extrauniversitarie**

Possono essere riconosciute competenze acquisite fuori dall'Università nei casi previsti dalla normativa vigente. La richiesta di riconoscimento sarà valutata dal Consiglio di corso di studio tenendo conto del numero massimo di crediti riconoscibili fissato nell'ordinamento didattico del corso.

Il riconoscimento potrà avvenire qualora l'attività sia ritenuta coerente con gli obiettivi formativi specifici del corso di studio.

#### **Art. 11 Tirocinio curricolare**

Il Corso di Studio prevede, a richiesta dello studente, la possibilità di svolgere un tirocinio curricolare secondo il Regolamento generale tirocini di Ateneo.

#### **Art. 12 Prova finale**

##### *Caratteristiche della prova finale*

La prova finale di laurea per il conseguimento della laurea magistrale consiste nella redazione e nella discussione pubblica di una tesi scritta ed elaborata in modo originale dallo studente, sotto la guida di un relatore, su un argomento coerente con gli obiettivi del corso di studio, che dimostri la padronanza degli argomenti, la capacità di operare in modo autonomo, di analizzare criticamente i risultati ottenuti e di comunicarli con efficacia.

##### *Modalità di svolgimento della prova finale*

La prova finale consiste nell'esposizione e discussione davanti alla Commissione di Laurea della tesi di laurea magistrale il cui argomento, scelto dallo studente, sia coerente con gli obiettivi formativi del Corso di Studio.

L'elaborato di tesi di laurea magistrale deve evidenziare una congrua attività svolta dallo studente nell'approfondimento della materia e degli strumenti modellistico- sperimentali ad essa associati, anche con riferimento ad aspetti di tipo progettuale.

La discussione dell'elaborato è pubblica, come previsto dal Regolamento didattico di Ateneo. L'argomento dell'elaborato progettuale è svolto sotto la supervisione di un Relatore. Possono essere Relatori i Responsabili di attività formative attivate presso l'Ateneo.

È ammesso a sostenere la prova finale lo studente che abbia acquisito tutti i crediti previsti dal regolamento didattico del Corso di Laurea Magistrale, ad eccezione di quelli relativi alla prova finale.

Il voto è espresso in una frazione di n/110. Il conferimento della lode richiede il giudizio unanime della Commissione.

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La Commissione Paritetica docenti-studenti ha espresso parere favorevole sulla coerenza dei crediti assegnati alle singole attività formative e gli specifici obiettivi formativi programmati, ai sensi dell'articolo 12 comma 3 del DM 270/04.

## DEGREE PROGRAMME TEACHING REGULATIONS

### Art. 1 Access requisites

In order to be admitted to the Master's Programme in Civil Engineering applicants need to have a Bachelor's degree, or another equivalent academic degree.

Furthermore, students must fulfill curriculum requirements, personal preparation requirements and language requirements as detailed in the following.

### Curriculum requirements

Admission is restricted to students fulfilling one of the following requirements:

#### *Requirement 1*

Having obtained an Italian first level academic degree either in class 8 (D.M. 509/99) or in class L-7 (ex D.M. 270/04).

#### *Requirement 2*

Having obtained an Italian first level academic degree in a class not listed under "Requirement 1" and having obtained the following minimum credits:

- a) at least 51 credits in the following sectors(SSD), ICAR/01, ICAR/02, ICAR/04, ICAR/05, ICAR/06, ICAR/07, ICAR/08, ICAR/09SSD; ICAR/10, ICAR/11, ICAR/17;

and

- b) At least 39 credits in the following sectors (SSD), ICAR/01, ICAR/02, ICAR/04, ICAR/05, ICAR/06, ICAR/07, ICAR/08, ICAR/09;

and

- c) At least 24 credits in the following sectors (SSD) MAT and FIS

#### *Requirement 3*

Having obtained a foreign academic degree, considered as eligible by an Admission Board appointed by the Board of the Degree Programme. Eligibility is evaluated based on the above criteria when it is possible to define an equivalent class for the foreign degree or when it is possible to identify equivalent scientific sectors (SSD) and credits for courses. If it is not possible to define an equivalent class or equivalent scientific sectors, the academic curriculum will be evaluated by the Admission Board.

For the admission students must demonstrate an English Language Proficiency no lower than B2 level according to the CEFR (Common European Framework of Reference for Languages).

### Personal Preparation Requirements

Personal preparation will be evaluated by an Admission Board appointed by the Board of the Degree Programme (Consiglio di Corso di studio). The Admission Board will evaluate the candidate academic merit, with reference to the final graduation grade, which will be considered adequate if not lower than 83/110. For applicants with a foreign title, a proper conversion will be carried out. For applicants that do not have yet obtained a Bachelor's degree, personal preparation is considered adequate if they have obtained at least 165 CFU with an average mark of 22/30 in the exams.

For applicants that do not fulfill the aforementioned criteria, admission is conditional to the assessment of the academic merit by the Admission Board, which will consider other elements such as:

- Exams scores;
- Duration of the studies in comparison with the legal duration on the Bachelor's Degree.

### Language Requirements

Admission to the Master's Programme requires an English knowledge level not lower than B2. The English knowledge level can be demonstrated through one of the following documents:

- English Knowledge certificates issued by the University of Bologna Language Centre (CLA-UNIBO), or other Italian Universities Language Centre.
- Internationally recognized language certifications, such as TOEFL, IELTS, etc. (minimum scores to be considered equivalent to B2 level being the following: IELTS 5,5; TOEFLPBT507-557; TOEFL CBT 180- 217; TOEFL IBT80-99; Cambridge First Certificate (FCE); Trinity College of London ISEII

- Entitled English Schools.

#### **Art. 2 Changing curriculum within the degree**

The degree programme is divided into curricula.

It is allowed to make a request to change curriculum within the degree, following the procedure published on the university's website.

#### **Art. 3 Individual study plans**

There is the possibility of submitting individual study plans with the methods, criteria and deadlines disclosed through the University Portal.

The individual study plans, approved by the Degree Programme Board, cannot however ignore compliance with the regulations and guidelines defined by the competent bodies.

If the study plan provides for the choice of learning activities activated in a restricted access degree programme, admission to the same must also be previously approved by the restricted access degree programme Board on the basis of criteria previously identified by it.

#### **Art. 4 Implementation of learning activities and types of teaching activities**

The published teaching plan indicates all the learning activities and their subdivision into hours of classroom teaching, practical exercises or internship, as well as the type of teaching methods. Any further information will be published annually on the Degree Programme website.

#### **Art. 5 Flexible pathway**

Students may opt for the flexible pathway that allows them to complete the Degree Programme in a shorter or longer time than the normal duration in accordance with the procedures defined in the University's Educational Regulations.

The educational activities envisaged by the study pathway may be replaced in the event of necessary deactivation, in order to guarantee the quality and sustainability of the educational offer

#### **Art. 6 Assessment of learning activities**

The attached teaching plan indicates all cases in which the learning activities end with an exam, marked with a grade out of 30 or on a pass-fail basis.

The assessment methods (oral exam, written exam, etc.) for each learning activity are laid down annually by the Degree Programme Board during the curriculum planning activities and are made available to the students prior to the start of lessons on the University portal.

#### **Art. 7 Activities freely chosen by the student - elective activities**

Students must choose from the elective courses listed in the course structure diagram, following the methods indicated in the structure itself and in the terms indicated annually and published on the University portal.

For each curriculum, the Degree Programme lists some course units/learning activities that are coherent with the learning outcomes of the programme and laid down in the attached teaching plan, which are recommended to complete the competencies in that specific subject area.

Students may choose one or more elective course units/learning activities from among those listed in the Degree Programme run at the University of Bologna.

Students wishing to sit the exam relative to a course unit running at the University of Bologna but not listed among those established for the Degree Programme, shall apply to do so to the Degree Programme Board in the terms laid down annually and published on the University portal. The Board will assess the coherence of the choice with the student's study programme.

#### **Art. 8 Criteria for the recognition of credits acquired in other Italian second-level degree programmes in the same class**

This article applies only to Students coming from an Italian second-level University degree conforming to the provisions of the Ministry Decree 270/2004 (Laurea magistrale), belonging to the LM-23 class.

The recognition is evaluated by the Degree Programme Board which checks the coherence of the whole study plan. Referring to degree programmes delivered in a language other than Italian, recognition refers to course units delivered or learning activities undertaken in that language or other foreign languages that are indicated every year by the Degree Programme Board.

#### **Art. 9 Recognition of credits acquired from Italian second-level degree programmes belonging to a different class, from e-learning programs, or from international second-level degree programmes.**

The credits may be recognized by the CIVILENGINEERING Board after an analysis based on the following

criteria:

- Total number of teaching hours of the course;
- Evaluation of the consistency of the sectors (or of the subjects, if the sectors are not defined), and of the contents of the courses whence the Student has acquired the credits, with the specific teaching objective of the CIVILENGINEERING Programme.

**Art. 10 Criteria for the recognition of extra-university competencies and skills**

Extra-university competencies might be recognized in the cases established by the law.

Such recognition will be evaluated by the Degree Programme Board, taking into account the maximum credit threshold set forth on the Degree Teaching Regulation.

The activity may be recognized as long as it is deemed consistent with the degree's learning outcomes.

**Art. 11 Internship**

The Degree Programme, upon request by the student, may authorize an internship, in compliance with the rules set forth by the Internship Regulation of the University of Bologna.

**Art. 12 Final exam**

The final examination consists in the presentation and discussion of a dissertation, on a topic coherent with the 2nd cycle degree programme learning outcomes, before an Examination Board. The dissertation must demonstrate the activities carried out by the student both in studying the subject and the modelling or experimental tools related to it, also referring to project and design activities. The topic or project is developed under the guidance of a UNIBO supervising professor.

Final examination terms and methods

L'elaborato di tesi di laurea magistrale deve evidenziare una congrua attività svolta dallo studente nell'approfondimento della materia e degli strumenti modellistico-sperimentali ad essa associati, anche con riferimento ad aspetti di tipo progettuale.

L'argomento della relazione o dell'elaborato progettuale è svolto sotto la supervisione di un Docente responsabile di un insegnamento attivato presso l'Ateneo. Il voto è espresso in cento decimi. Il conferimento della lode richiede il giudizio unanime della Commissione.

The final examination is open to students having obtained all the required credits in their specific curriculum, with the exception of those relative to the final examination, in any case following the normal duration of the Degree Programme. The final examination consists in the presentation and discussion of a dissertation, on a topic coherent with the 2nd cycle degree programme learning outcomes, before an Examination Board. The final exam must show the Student's ability to master the subject and the experimental and modelling methods associated to it. The topic or project is developed under the guidance of a UNIBO supervising professor. The Thesis' discussion is public.

The grade is expressed out of one hundred and ten. Honours may be granted at the unanimous decision of the Board.

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The Faculty-student Joint Committee expressed its favorable opinion under the terms of article 12 para. 3 of Ministerial Decree no.270/04.

**Anno Accademico** 2026/2027  
**Classe** LM-23 R-INGEGNERIA CIVILE  
**Corso** 6708-CIVIL ENGINEERING

### Curriculum: WATER ENGINEERING (C97)

#### Primo Anno di Corso

##### Gruppo: 1) Mandatory courses

**TAF:** Ambito:

**Cfu min:** Cfu max:

Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6708 000 000 72756 - 0 - ADVANCED DESIGN OF STRUCTURES		ICAR/09	CEAR-07/A		9	72/0/0/0	No	Voto

**Ambito:** 206 - Ingegneria civile

**Obiettivi:** Students will gain in-depth knowledge of the structural behavior of reinforced concrete (Module 1), prestressed concrete, steel, and composite structures (Module 2). They will introduced to advanced concepts and methods for the verification, modeling, and design of these structures, covering topics such as: failure and serviceability limit states, the role of ductility at both sectional and structural levels, longterm effects (including concrete creep, shrinkage, and steel relaxation), the effects of precompression on RC elements, plates under transverse loads, cylindrical shells and tanks, bracing systems, built-up steel columns, buckling issues, and stud bolt connectors in composite beams.

By the end of the course, students will be able to develop preliminary design and verifications of steel and RC structures (frames and plates), both in terms of ultimate and serviceability limit states; they could also determine the amount of reinforcement and draw the most important structural details. They will be also equipped to independently tackle the preliminary design of cylindrical tanks and prestressed beams. Reference will be made to European standards.

**Obiettivi inglese:** Students will gain in-depth knowledge of the structural behavior of reinforced concrete (Module 1), prestressed concrete, steel, and composite structures (Module 2). They will introduced to advanced concepts and methods for the verification, modeling, and design of these structures, covering topics such as: failure and serviceability limit states, the role of ductility at both sectional and structural levels, longterm effects (including concrete creep, shrinkage, and steel relaxation), the effects of precompression on RC elements, plates under transverse loads, cylindrical shells and tanks, bracing systems, built-up steel columns, buckling issues, and stud bolt connectors in composite beams.

By the end of the course, students will be able to develop preliminary design and verifications of steel and RC structures (frames and plates), both in terms of ultimate and serviceability limit states; they could also determine the amount of reinforcement and draw the most important structural details. They will be also equipped to independently tackle the preliminary design of cylindrical tanks and prestressed beams. Reference will be made to European standards.

6708 000 000 72757 - 0 - ADVANCED HYDROSYSTEMS ENGINEERING	ICAR/02	CEAR-01/B	9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: 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.</p> <p>Obiettivi inglese: 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.</p>						
6708 000 000 72758 - 0 - ADVANCED STRUCTURAL MECHANICS	ICAR/08	CEAR-06/A	9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance students' understanding of structural behavior and enhance their ability to apply structural analysis methods to civil engineering structures. Students will acquire knowledge in the following areas: Structural Matrix Analysis, i.e., techniques for analyzing 2D truss and frame structures using the Direct Stiffness Method and FEM software. Buckling Analysis, i.e., methods for buckling and post-buckling analysis of discrete and continuous systems, with FEM applications. Plastic Analysis, i.e., concepts of plasticity, incremental and limit analysis for truss and beam systems, also using FEM tools. The main skills developed during this course include: Proficiency in matrix analysis and the Finite Element Method (FEM) for analyzing truss and frame structures. Ability to evaluate buckling and post-buckling behavior of rigid and continuous systems, using equilibrium and energy methods. Competence in conducting plastic analysis of structural systems, including an understanding of plastic hinges. Software Proficiency: hands-on experience with FEM-based software for solving structural, buckling, and elasto-plastic problems. Analytical and critical thinking: enhanced ability to approach complex structural issues with theoretical and computational tools. The course contributes to the objectives of the master's program related to the application of mathematical tools for interpreting, describing, and modeling structural problems.</p> <p>Obiettivi inglese: The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance students' understanding of structural behavior and enhance their ability to apply structural analysis methods to civil engineering structures. Students will acquire knowledge in the following areas: Structural Matrix Analysis, i.e., techniques for analyzing 2D truss and frame structures using the Direct Stiffness Method and FEM software. Buckling Analysis, i.e., methods for buckling and post-buckling analysis of discrete and continuous systems, with FEM applications. Plastic Analysis, i.e., concepts of plasticity, incremental and limit analysis for truss and beam systems, also using FEM tools. The main skills developed during this course include: Proficiency in matrix analysis and the Finite Element Method (FEM) for analyzing truss and frame structures. Ability to evaluate buckling and post-buckling behavior of rigid and continuous systems, using equilibrium and energy methods. Competence in conducting plastic analysis of structural systems, including an understanding of plastic hinges. Software Proficiency: hands-on experience with FEM-based software for solving structural, buckling, and elasto-plastic problems. Analytical and critical thinking: enhanced ability to approach complex structural issues with theoretical and computational tools. The course contributes to the objectives of the master's program related to the application of mathematical tools for interpreting, describing, and modeling structural problems.</p>						
6708 000 000 72765 - 0 - GEOTECHNICAL ENGINEERING	ICAR/07	CEAR-05/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: The course aims to provide students with in-depth knowledge and practical skills in advanced soil mechanics and geotechnical modeling, focusing on applications in civil engineering design. By the end of the course, students will have gained a comprehensive understanding of the fundamental and advanced principles of soil behavior under various loading conditions, which are essential for assessing soil-structure interaction. They will acquire knowledge of geotechnical characterization methods, applicable both in laboratory and in situ, aligning with the program's objective to prepare students for design, construction, and stability assessments in civil engineering. In terms of skills, students will be proficient in evaluating and comparing key physical and mechanical soil parameters through experimental testing, integrating techniques from soil mechanics for geotechnical assessments. They will also be capable of applying geotechnical models for the design and stability analysis of primary geotechnical structures, in line with the CdS's emphasis on operational and methodological expertise in civil structure and infrastructure projects. Furthermore, students will develop the competence to conduct analyses of foundation and retaining structure stability, including complex soil behaviors and ensuring reliable, safety-oriented designs.</p> <p>Obiettivi inglese: The course aims to provide students with in-depth knowledge and practical skills in advanced soil mechanics and geotechnical modeling, focusing on applications in civil engineering design. By the end of the course, students will have gained a comprehensive understanding of the fundamental and advanced principles of soil behavior under various loading conditions, which are essential for assessing soil-structure interaction. They will acquire knowledge of geotechnical characterization methods, applicable both in laboratory and in situ, aligning with the program's objective to prepare students for design, construction, and stability assessments in civil engineering. In terms of skills, students will be proficient in evaluating and comparing key physical and mechanical soil parameters through experimental testing, integrating techniques from soil mechanics for geotechnical assessments. They will also be capable of applying geotechnical models for the design and stability analysis of primary geotechnical structures, in line with the CdS's emphasis on operational and methodological expertise in civil structure and infrastructure projects. Furthermore, students will develop the competence to conduct analyses of foundation and retaining structure stability, including complex soil behaviors and ensuring reliable, safety-oriented designs.</p>						

6708 000 000 72764 - 0 - NUMERICAL METHODS

MAT/08

MATH-05/A

12

96/0/0/0

No

Voto

**Ambito:** 2019 - Attività formative affini o integrative

C

Obiettivi: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to recognize, analyze and solve numerically on the computer some classes of mathematical problems naturally arising from modelling of physical systems subject to simulation/design in civil engineering.

Students will acquire knowledge in the following areas: (1) fundamentals of numerical analysis, such as types of numerical errors, machine numbers, posedness and conditioning of mathematical problems, convergence, stability, accuracy and (spatial and temporal) efficiency of numerical methods; (2) numerical solution of systems of linear equations; (3) numerical solution of non-linear equations and systems of non-linear equations; (4) numerical interpolation and approximation (fitting) of data and functions; (5) numerical differentiation and integration (quadrature) of functions; (6) numerical solution of (linear) differential equations of elliptic, parabolic and hyperbolic type, with focus on the finite difference method and some mention of the finite element method.

The main skills developed during this course include: (1) proficiency in recognizing classes of mathematical problems, analyzing them from posedness and conditioning point of views and, hence, predicting the difficulty of their numerical solution; (2) ability to choose the numerical method suitable for the solution of some classes of mathematical problems in accordance with the desired accuracy-efficiency tradeoff; (3) software competence: hands-on experience with using Matlab software and its programming language to implement algorithms and, in particular, numerical methods; (4) analytical and critical thinking: enhanced ability both to figure out the numerical algorithms running at the core of widely used simulation /design softwares in civil engineering, and to interpret their outputs from the numerical perspective.

The course contributes to the objectives of the master's program by completing and complementing the theoretical mathematical preparation acquired by students during the bachelor's degree with the knowledge and ability to solve numerically (on the computer) classes of mathematical problems of interest to civil engineering.

Obiettivi inglese: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to recognize, analyze and solve numerically on the computer some classes of mathematical problems naturally arising from modelling of physical systems subject to simulation/design in civil engineering.

Students will acquire knowledge in the following areas: (1) fundamentals of numerical analysis, such as types of numerical errors, machine numbers, posedness and conditioning of mathematical problems, convergence, stability, accuracy and (spatial and temporal) efficiency of numerical methods; (2) numerical solution of systems of linear equations; (3) numerical solution of non-linear equations and systems of non-linear equations; (4) numerical interpolation and approximation (fitting) of data and functions; (5) numerical differentiation and integration (quadrature) of functions; (6) numerical solution of (linear) differential equations of elliptic, parabolic and hyperbolic type, with focus on the finite difference method and some mention of the finite element method.

The main skills developed during this course include: (1) proficiency in recognizing classes of mathematical problems, analyzing them from posedness and conditioning point of views and, hence, predicting the difficulty of their numerical solution; (2) ability to choose the numerical method suitable for the solution of some classes of mathematical problems in accordance with the desired accuracy-efficiency tradeoff; (3) software competence: hands-on experience with using Matlab software and its programming language to implement algorithms and, in particular, numerical methods; (4) analytical and critical thinking: enhanced ability both to figure out the numerical algorithms running at the core of widely used simulation /design softwares in civil engineering, and to interpret their outputs from the numerical perspective.

The course contributes to the objectives of the master's program by completing and complementing the theoretical mathematical preparation acquired by students during the bachelor's degree with the knowledge and ability to solve numerically (on the computer) classes of mathematical problems of interest to civil engineering.

6708 000 000 95714 - 0 - SUSTAINABLE TRANSPORT SYSTEM DESIGN

ICAR/05

CEAR-03/B

9

72/0/0/0

No

Voto

**Ambito:** 206 - Ingegneria civile

B

Obiettivi: The course of Sustainable Transport System Design is split into two modules: the Sustainable Transportation Engineering module covers the basic elements of transportation systems engineering with reference to sustainable transport modelling and planning, while the Urban road mobility design and maintenance module focuses on the design of infrastructure to improve the sustainability of transport systems. The objective of the "Sustainable Transportation Engineering" module is to provide students with knowledge on sustainable transport planning framework. The module delves into supply- and demand-oriented methods and policies aimed at improving the environmental efficiency of transport systems. Students will learn theoretical and practical skills to model and simulate users' behaviour and transport systems performances and impacts, also in the context of new transportation technologies.

Obiettivi inglese: The course of Sustainable Transport System Design is split into two modules: the Sustainable Transportation Engineering module covers the basic elements of transportation systems engineering with reference to sustainable transport modelling and planning, while the Urban road mobility design and maintenance module focuses on the design of infrastructure to improve the sustainability of transport systems. The

objective of the "Sustainable Transportation Engineering" module is to provide students with knowledge on sustainable transport planning framework. The module delves into supply- and demand-oriented methods and policies aimed at improving the environmental efficiency of transport systems. Students will learn theoretical and practical skills to model and simulate users' behaviour and transport systems performances and impacts, also in the context of new transportation technologies.

**Gruppo: 2) Elective courses****TAF: F Ambito: 1147 - Altre conoscenze utili per****Cfu min: 6 Cfu max: 6**

Note:

**Attività formativa****TIP****SSD****SSD 2024****TAF****CFU****ORE F/E/L/N****FREQ. VER.**

6708 000 000 B8640 - 0 - ROAD AND TRANSPORTATION ENGINEERING DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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**Ambito:** 0000 - Nessun Ambito

F

**Obiettivi:** Students attending the course will develop the design of a road infrastructure, acquiring knowledge about the specific design standards and procedures. In particular the course will focus on the construction of a roundabout instead of an intersection in a real urban context. The student will obtain the skills necessary to design a roundabout in terms of pavement design, geometry and road signs. Interaction and collaboration between students will be fostered through the group work on the project.

**Obiettivi inglese:** Students attending the course will develop the design of a road infrastructure, acquiring knowledge about the specific design standards and procedures. In particular the course will focus on the construction of a roundabout instead of an intersection in a real urban context. The student will obtain the skills necessary to design a roundabout in terms of pavement design, geometry and road signs. Interaction and collaboration between students will be fostered through the group work on the project.

6708 000 000 B8638 - 0 - STRUCTURAL ENGINEERING DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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**Ambito:** 0000 - Nessun Ambito

F

**Obiettivi:** Students attending the course will delve into the study of the topics concerning the design of civil structures, acquiring knowledge about the specific design standards and procedures. Basic theoretical concepts, covered in other courses, will be recalled with the objective of applying them for the development of a project, regarding the design of a reinforced concrete building under static loading conditions. Students will also learn the use of a finite element software for the structural analysis and will develop blueprints using a CAD software. Interaction and collaboration between students will be fostered through the group work on the project.

**Obiettivi inglese:** Students attending the course will delve into the study of the topics concerning the design of civil structures, acquiring knowledge about the specific design standards and procedures. Basic theoretical concepts, covered in other courses, will be recalled with the objective of applying them for the development of a project, regarding the design of a reinforced concrete building under static loading conditions. Students will also learn the use of a finite element software for the structural analysis and will develop blueprints using a CAD software. Interaction and collaboration between students will be fostered through the group work on the project.

6708 000 000 B8639 - 0 - WATER ENGINEERING AND CLIMATE CHANGE ADAPTATION DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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**Ambito:**

F

**Obiettivi:** Students attending the course will delve into water engineering design projects. Students will acquire knowledge on standards and procedures towards resilient design solutions under changing climatic and socioeconomic conditions. Students will learn the use of open source softwares to analyse the water cycle and related hydraulic problems. Interaction and collaboration between students will be fostered through group activities during classes.

**Obiettivi inglese:** Students attending the course will delve into water engineering design projects. Students will acquire knowledge on standards and procedures towards resilient design solutions under changing climatic and socioeconomic conditions. Students will learn the use of open source softwares to analyse the water cycle and related hydraulic problems. Interaction and collaboration between students will be fostered through group activities during classes.

## Secondo Anno di Corso

### Gruppo: 1) Mandatory courses

**TAF:** Ambito:

**Cfu min:** Cfu max:

Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 72767 - 0 - MANAGING ENGINEERING AND CONSTRUCTION PROCESSES

ING-IND/35

IEGE-01/A

6

48/0/0/0

No

Voto

**Ambito:** 2019 - Attività formative affini o integrative

C

Obiettivi: A successful learner of this course will know the principles, methods and tools needed to manage and design construction processes. In addition, he or she will master elements of planning, estimation, scheduling, bidding and contractual relations, project cash flow evaluation, critical path method, as well as cost and effectiveness control.

Development of knowledge and skills:

- Knowledge:

Students will gain a deep understanding of projects in contemporary organizations. They will learn how to initiate, plan and execute a project, following it through its various phases. In addition, students will explore key approaches and theories for successful project management.

- Skills:

Through real-world case studies, problems and exercises, students will develop the ability to apply theoretical knowledge to real-world scenarios. During the course, project managers and entrepreneurs will come to class to share their experiences and comment on the opportunities and threats of managing complex projects around the world.

- Consistency with program objectives:

This course is designed to complement the overall objectives of the master's program by focusing on management-related topics that engineers should know in order to successfully enter the job market and advance in their professional careers.

Obiettivi inglese: A successful learner of this course will know the principles, methods and tools needed to manage and design construction processes. In addition, he or she will master elements of planning, estimation, scheduling, bidding and contractual relations, project cash flow evaluation, critical path method, as well as cost and effectiveness control.

Development of knowledge and skills:

- Knowledge:

Students will gain a deep understanding of projects in contemporary organizations. They will learn how to initiate, plan and execute a project, following it through its various phases. In addition, students will explore key approaches and theories for successful project management.

- Skills:

Through real-world case studies, problems and exercises, students will develop the ability to apply theoretical knowledge to real-world scenarios. During the course, project managers and entrepreneurs will come to class to share their experiences and comment on the opportunities and threats of managing complex projects around the world.

- Consistency with program objectives:

This course is designed to complement the overall objectives of the master's program by focusing on management-related topics that engineers should know in order to successfully enter the job market and advance in their professional careers.

6708 000 000 B8637 - 0 - SEMINARI IN LINGUA ITALIANA SULL'INGEGNERIA CIVILE

3

0/0/24/0

No

Giudizio

**Ambito:** 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro

F

Obiettivi: Course provides an updated overview of technological innovations in Civil Engineering, promotes understanding of environmental and sustainability challenges, encourages multidisciplinary collaboration and contributes to developing practical and applied skills, offering students the opportunity to develop hands-on skills through case studies workshops that allow them to apply theoretical concepts to real-world and contemporary scenarios. Furthermore the course promotes skills relates to the proficient use of technical language in Italian.

Obiettivi inglese: Course provides an updated overview of technological innovations in Civil Engineering, promotes understanding of environmental and sustainability challenges, encourages multidisciplinary collaboration and contributes to developing practical and applied skills, offering students the opportunity to develop hands-on skills through case studies workshops that allow them to apply theoretical concepts to real-world and contemporary scenarios. Furthermore the course promotes skills relates to the proficient use of technical language in Italian.

**Gruppo: 2) Elective courses****TAF: B Ambito: 206 - Ingegneria civile****Cfu min: 24 Cfu max: 24**

Note: Choose 24 credits among the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 95709 - 0 - CLIMATE CHANGE ADAPTATION	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p>Obiettivi: Students of this course will learn solutions to climate change adaptation and their technical design, by focusing on extreme weather events - in particular floods and droughts - low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as an effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design.</p> <p>The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent re-search developments and will make use of open access information.</p> <p>Obiettivi inglese: Students of this course will learn solutions to climate change adaptation and their technical design, by focusing on extreme weather events - in particular floods and droughts - low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as an effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design.</p> <p>The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent re-search developments and will make use of open access information.</p>						
6708 000 000 78594 - 0 - FLOOD AND DROUGHT RISK MANAGEMENT	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b></p> <p>Obiettivi: The objective of this course is to provide students with the understanding of the factors causing floods and droughts and with the knowledge both of the methods for quantifying and of the options for reducing such water risks. By the end of the course, students have the knowledge of the data requirement and methods used for the assessment of river flood and drought risk, in terms of hazard, exposure and vulnerability. Students will also learn about the measures available for mitigating and managing such risks (such as structures for flood defense, flood and drought policies/plans/mapping; forecasting and warning systems). Applied skills: through the development of the assignments, students will apply their knowledge to obtain and process their own real-world meteo-hydrological data and to use them for i) computing meteorological and hydrological drought indicators and ii) estimating design floods.</p> <p>Obiettivi inglese: The objective of this course is to provide students with the understanding of the factors causing floods and droughts and with the knowledge both of the methods for quantifying and of the options for reducing such water risks. By the end of the course, students have the knowledge of the data requirement and methods used for the assessment of river flood and drought risk, in terms of hazard, exposure and vulnerability. Students will also learn about the measures available for mitigating and managing such risks (such as structures for flood defense, flood and drought policies/plans/mapping; forecasting and warning systems). Applied skills: through the development of the assignments, students will apply their knowledge to obtain and process their own real-world meteo-hydrological data and to use them for i) computing meteorological and hydrological drought indicators and ii) estimating design floods.</p>						
6708 000 000 B5516 - 0 - GEOMATICS FOR GIS	ICAR/06	CEAR-04/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p>Obiettivi: Il corso approfondisce l'uso dei Sistemi Informativi Geografici (GIS) e le moderne tecnologie offerte dalla Geomatica per la raccolta, la gestione e l'analisi dei dati geospaziali. Gli studenti acquisiscono consapevolezza delle potenzialità e dei limiti delle tecniche di rappresentazione metrica del territorio o di specifiche infrastrutture, specialmente in termini di accuratezza e produttività, e apprendono come sceglierle ed integrarle per supportare diverse applicazioni dell'ingegneria ambientale e civile.</p> <p>Obiettivi inglese: The course provides insights into the use of Geographical Information Systems (GIS) and the modern technologies offered by Geomatics to collect, manage and analyse geospatial data. Students gain awareness on potentials and limitations of the techniques for the metric representation of the landscape or of specific infrastructures, especially in terms of accuracy and productivity, and learn how to choose and integrate them to support different environmental and civil engineering applications.</p>						
6708 000 000 78593 - 0 - GROUNDWATER AND CONTAMINATION PROCESSES	ICAR/01	CEAR-01/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p>Obiettivi: The course provides fundamentals of subsurface flow and transport, emphasizing the primary role of groundwater in the hydrologic cycle, the relation of groundwater flow to hydrogeological properties, and the management of contaminated groundwater. Effective methods for the prediction and interpretation of groundwater processes will be discussed together with engineering implications. These include basics of infrastructure design related to the subsurface environment. Particular attention will be reserved to well hydraulics having several implications in water exploitation, monitoring and remediation. Description and analysis of both synthetic and real case studies will provide the opportunity to jointly apply concepts and methods discussed during the course.</p> <p>Obiettivi inglese: The course provides fundamentals of subsurface flow and transport, emphasizing the primary role of groundwater in the hydrologic cycle, the relation of groundwater flow to hydrogeological properties, and the management of contaminated groundwater. Effective methods for the prediction and interpretation of groundwater processes will be discussed together with engineering implications. These include basics of infrastructure design related to the subsurface environment. Particular attention will be reserved to well hydraulics having several implications in water exploitation, monitoring and remediation. Description and analysis of both synthetic and real case studies will provide the opportunity to jointly apply concepts and methods discussed during the course.</p>						

6708 000 000 95813 - 0 - LARGE-SCALE WATER STRUCTURES	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
			B			
<p><b>Ambito:</b>            Obiettivi: Students will learn advanced theoretical concepts and operational tools for the design of large-scale water structures, including dams, reservoirs and hydro-power systems. Students will gain expertise on the hydraulic and management challenges of large-scale water structures and their environmental impact. Students will be able to check dam stability, design key hydraulic facilities and large-scale hydro-power plants. Case studies related to recently built water structures will be examined.</p> <p>Obiettivi inglese: Students will learn advanced theoretical concepts and operational tools for the design of large-scale water structures, including dams, reservoirs and hydro-power systems. Students will gain expertise on the hydraulic and management challenges of large-scale water structures and their environmental impact. Students will be able to check dam stability, design key hydraulic facilities and large-scale hydro-power plants. Case studies related to recently built water structures will be examined.</p>						

6708 000 000 81509 - 0 - SUSTAINABLE ROAD INFRASTRUCTURES	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
			B			
<p><b>Ambito:</b>            Obiettivi: Students will be introduced to road engineering and learn how these transportation infrastructures are conceived. A range of different externalities will be addressed and evaluated in order to identify the possible sustainable approaches towards the design and construction of less impacting roads. Emerging topics such as territory fragmentation and soil-bio engineering will be imparted as possible multidisciplinary solutions for the novel civil engineer that will know how to evaluate the impact of a road infrastructure on the territory and how to design the interventions to mitigate these effects, for a more sustainable infrastructure.</p> <p>Obiettivi inglese: Students will be introduced to road engineering and learn how these transportation infrastructures are conceived. A range of different externalities will be addressed and evaluated in order to identify the possible sustainable approaches towards the design and construction of less impacting roads. Emerging topics such as territory fragmentation and soil-bio engineering will be imparted as possible multidisciplinary solutions for the novel civil engineer that will know how to evaluate the impact of a road infrastructure on the territory and how to design the interventions to mitigate these effects, for a more sustainable infrastructure.</p>						

### Gruppo: 3) Final examination

TAF: **Ambito:**

**Cfu min: 15 Cfu max: 15**

Note: Students can choose only the "Final examination" (Group A) or the "Final examination" and one of the learning activities among "Internship for preparation for the final examination", "Internship abroad for preparation for the final examination" or "Preparation for the final examination abroad" (Group B).

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ. VER.
3.1) Gruppo A					0-15		
6708 000 000 60750 - 0 - FINAL EXAMINATION					15	0/0/0/0	No
<p><b>Ambito:</b> 1018 - Per la prova finale            Obiettivi: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.</p> <p>Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.</p>				E			
3.2) Gruppo B					0-15		
6708 000 000 86301 - 0 - FINAL EXAMINATION					3	0/0/0/0	No
<p><b>Ambito:</b> 1018 - Per la prova finale            Obiettivi: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.</p> <p>Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.</p>				E			

6708 000 000 84551 - 1 - INTERNSHIP ABROAD FOR PREPARATION OF THE FINAL EXAMINATION	12	0/0/300/0	No	Giudizio
<b>Ambito:</b> 1018 - Per la prova finale	E			
Obiettivi: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.				
Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.				
6708 000 000 86296 - 1 - INTERNSHIP FOR PREPARATION FOR THE FINAL EXAMINATION	12	0/0/300/0	No	Giudizio
<b>Ambito:</b> 1018 - Per la prova finale	E			
Obiettivi: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.				
Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.				
6708 000 000 84548 - 1 - PREPARATION FOR THE FINAL EXAMINATION ABROAD	12	0/0/300/0	No	Giudizio
<b>Ambito:</b> 1018 - Per la prova finale	E			
Obiettivi: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.				
Obiettivi inglese: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.				

**Gruppo: 4) Courses freely chosen by the student****TAF: D Ambito: 1008 - A scelta dello studente****Cfu min: 12 Cfu max: 12**

Note: Choose 12 credits. The course board suggests to attend to the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6708 000 000 72803 - 0 - BIOTECHNOLOGY FOR THE SUSTAINABLE RECLAMATION OF CONTAMINATED LANDS AND WATERS		ICAR/03	CEAR-02/A		6	48/0/0/0	No	Voto
<b>Ambito:</b>				D				
Obiettivi: 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.								
Obiettivi inglese: 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.								
6708 000 000 86582 - 0 - BUILDING INFORMATION MODELING		ICAR/17	CEAR-10/A		6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile				D				
Obiettivi: Il corso mira a formare gli allievi sull'ampio e crescente panorama degli strumenti di modellazione BIM fornendo il lessico di questa nuova forma di rappresentazione ed i metodi che stanno alla base del workflow integrato ad essa riferibile. Il corso prende in esame gli step alla base della BIM Technology e le novità da essa introdotta rispetto all'approccio alla progettazione, al controllo ed alla gestione del processo costruttivo. Viene, inoltre, fornita una ampia panoramica sull'insieme degli applicativi BIM ad oggi presenti sul mercato in modo da fornire gli strumenti critici per la valutazione degli applicativi più idonei alle esigenze progettuali.								
Obiettivi inglese: The course aims at training students on the broad and expanding field of BIM applications by providing a general lexicon, the concepts and techniques of this wide set of tools for management, representation and construction. Starting from a short summary of consolidated modelling techniques (CAD, 3D geometric modelling tools), the course considers both the "pillars" of BIM Technology (datum, contents, views, management) and the innovations introduced in the construction process by this approach to design. The course also provides a comprehensive overview of the main BIM applications currently in use, in order to develop a critical approach to these techniques and evaluate the most suitable solution to design issues.								

6708 000 000 95709 - 0 - CLIMATE CHANGE ADAPTATION	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p>Obiettivi: Students of this course will learn solutions to climate change adaptation and their technical design, by focusing on extreme weather events - in particular floods and droughts - low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as an effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design.</p> <p>The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent re-search developments and will make use of open access information.</p> <p>Obiettivi inglese: Students of this course will learn solutions to climate change adaptation and their technical design, by focusing on extreme weather events - in particular floods and droughts - low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as an effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design.</p> <p>The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent re-search developments and will make use of open access information.</p>						
6708 000 000 72797 - 0 - COASTAL ENGINEERING	ICAR/01	CEAR-01/A	6	48/0/0/0	No	Voto
D						
<p><b>Ambito:</b></p> <p>Obiettivi: Aim of the course is to provide knowledge about ocean and coastal processes and tools for the design of ocean and coastal structures. The students will learn: i) the processes of wave generation and transformation from off-shore to shore; ii) the wave-structure interaction processes; iii) how to size a stable harbour breakwater and how to minimise its environmental impact thanks to specific design mitigation options; iv) the principles of marine renewable energy, with specific focus on wave energy devices; v) the fundamentals of sustainable blue growth, including multi-use marine areas.</p> <p>Obiettivi inglese: Aim of the course is to provide knowledge about ocean and coastal processes and tools for the design of ocean and coastal structures. The students will learn: i) the processes of wave generation and transformation from off-shore to shore; ii) the wave-structure interaction processes; iii) how to size a stable harbour breakwater and how to minimise its environmental impact thanks to specific design mitigation options; iv) the principles of marine renewable energy, with specific focus on wave energy devices; v) the fundamentals of sustainable blue growth, including multi-use marine areas.</p>						
6708 000 000 72769 - 0 - COMPUTATIONAL MECHANICS	ICAR/08	CEAR-06/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b></p> <p>Obiettivi: The Computational Mechanics course aims to provide students with the knowledge of the finite element method for solid and structural mechanics problems. Through this course, students will gain the theoretical and practical skills necessary to develop and implement the finite element method for a wide range of structural engineering problems and critically analyse the results. There is a strong emphasis on the computer implementation of algorithms in programming assignments. The application to real engineering problems is stressed throughout the course.</p> <p>Obiettivi inglese: The Computational Mechanics course aims to provide students with the knowledge of the finite element method for solid and structural mechanics problems. Through this course, students will gain the theoretical and practical skills necessary to develop and implement the finite element method for a wide range of structural engineering problems and critically analyse the results. There is a strong emphasis on the computer implementation of algorithms in programming assignments. The application to real engineering problems is stressed throughout the course.</p>						
6708 000 000 B5615 - 0 - COMPUTATIONAL WIND ENGINEERING	ICAR/08	CEAR-06/A	6	48/0/0/0	No	Voto
D						
<p><b>Ambito:</b> 1008 - A scelta dello studente</p> <p>Obiettivi: The course presents the methodologies to be used for the analysis of wind sensitive structures, with particular emphasis on the use of Computational Fluid Dynamics (CFD). The goal of the course is to provide the students with the fundamental concepts and operating tools to solve current Wind Engineering problems using CFD. Students will gain competences regarding the arrangement of the wind flow around immersed obstacles, the generation of aerodynamic forces for streamlined and bluff bodies, as well as aeroelastic interactions.</p> <p>Obiettivi inglese: The course presents the methodologies to be used for the analysis of wind sensitive structures, with particular emphasis on the use of Computational Fluid Dynamics (CFD). The goal of the course is to provide the students with the fundamental concepts and operating tools to solve current Wind Engineering problems using CFD. Students will gain competences regarding the arrangement of the wind flow around immersed obstacles, the generation of aerodynamic forces for streamlined and bluff bodies, as well as aeroelastic interactions.</p>						

6708 000 000 92874 - 0 - DESIGN OF FOUNDATIONS AND RETAINING STRUCTURES	ICAR/07	CEAR-05/A	6	48/0/0/0	No	Voto
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**Ambito:**

B

Obiettivi: The course aims to apply the knowledge of geotechnical engineering to the design of civil engineering structures. Upon successful completion, students will be able to: understand the possible soil-structure interaction mechanisms of shallow and deep foundations; assess the modes of failure of rigid and flexible retaining structures; identify the fundamental features of well-established and more advanced analysis methods; recognize the potential of numerical methods, including the finite element method (FEM). The primary skills students will develop include: proficiency in selecting suitable soil parameters and alternative strategies for the design of foundations and retaining structures; competence in using software tools for geotechnical engineering; ability to apply relevant design codes and standards to geotechnical design.

Obiettivi inglese: The course aims to apply the knowledge of geotechnical engineering to the design of civil engineering structures. Upon successful completion, students will be able to: understand the possible soil-structure interaction mechanisms of shallow and deep foundations; assess the modes of failure of rigid and flexible retaining structures; identify the fundamental features of well-established and more advanced analysis methods; recognize the potential of numerical methods, including the finite element method (FEM). The primary skills students will develop include: proficiency in selecting suitable soil parameters and alternative strategies for the design of foundations and retaining structures; competence in using software tools for geotechnical engineering; ability to apply relevant design codes and standards to geotechnical design.

6708 000 000 72781 - 0 - EARTHQUAKE ENGINEERING	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
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**Ambito:**

B

Obiettivi: The course covers a blend of theoretical knowledge and practical skills aimed at understanding and mitigating the effects of seismic actions on civil engineering structures. Students will acquire knowledge on the following areas: seismology fundamentals, i.e. understanding the causes and mechanics of earthquakes; Structural Dynamics: i.e. how structures respond to dynamic loads, including single degree of freedom systems and multi degree of freedom systems; Hazard Assessment, i.e. learning methods for assessing seismic hazard in a given region; Elastic and Inelastic Response spectra; Earthquake Actions and Design Codes, i.e. structural analysis methods and seismic design criteria according to Eurocode 8 and Italian code; Performance-Based Design, i.e. approaches that consider different performance requirements for structures for different seismic ground motion intensities. The main skills developed are: ability to analyze seismic data and apply theoretical concepts to real-world scenarios; proficiency in using software tools for seismic structural analysis; competence in creating designs that comply with seismic standards, with reference to reinforced concrete structures; ability to convey technical information effectively. The course contributes to the objectives of the master's course related to structural design and natural risk management.

Obiettivi inglese: The course covers a blend of theoretical knowledge and practical skills aimed at understanding and mitigating the effects of seismic actions on civil engineering structures. Students will acquire knowledge on the following areas: seismology fundamentals, i.e. understanding the causes and mechanics of earthquakes; Structural Dynamics: i.e. how structures respond to dynamic loads, including single degree of freedom systems and multi degree of freedom systems; Hazard Assessment, i.e. learning methods for assessing seismic hazard in a given region; Elastic and Inelastic Response spectra; Earthquake Actions and Design Codes, i.e. structural analysis methods and seismic design criteria according to Eurocode 8 and Italian code; Performance-Based Design, i.e. approaches that consider different performance requirements for structures for different seismic ground motion intensities. The main skills developed are: ability to analyze seismic data and apply theoretical concepts to real-world scenarios; proficiency in using software tools for seismic structural analysis; competence in creating designs that comply with seismic standards, with reference to reinforced concrete structures; ability to convey technical information effectively. The course contributes to the objectives of the master's course related to structural design and natural risk management.

6708 000 000 72805 - 0 - ENGINEERING GEOLOGY	GEO/05	GEOS-03/B	6	48/0/0/0	No	Voto
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**Ambito:**

D

Obiettivi: Engineering Geology explores engineering and environmental challenges stemming from interactions between geology and human activities, aiming to build understanding of geological processes and their impact on engineering design.

Upon successful completion of this course, students will be able to:

Analyze Geological Processes: Demonstrate a comprehensive understanding of geological and geomorphological processes, assessing their implications for engineering and environmental projects.

Interpret Geological Data: Critically analyze and interpret geological data from various sources, including maps and site investigation reports, to make informed engineering geological decisions.

Assess Geological Hazards: Evaluate geological hazards, with a focus on mass movements, and develop geological models to inform engineering decisions.

Develop Preventive and Remedial Measures: Formulate strategies to prevent and mitigate the impacts of geological hazards, with a focus on mass movements, including recommendations for site-specific interventions.

Collaborate with Multidisciplinary Teams: Communicate effectively with professionals across disciplines, contributing geological insights to multidisciplinary engineering and environmental design.

Obiettivi inglese: Engineering Geology explores engineering and environmental challenges stemming from interactions between geology and human activities, aiming to build understanding of geological processes and their impact on engineering design.

Upon successful completion of this course, students will be able to:

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Interpret Geological Data: Critically analyze and interpret geological data from various sources, including maps and site investigation reports, to make informed engineering geological decisions.

Assess Geological Hazards: Evaluate geological hazards, with a focus on mass movements, and develop geological models to inform engineering decisions.

Develop Preventive and Remedial Measures: Formulate strategies to prevent and mitigate the impacts of geological hazards, with a focus on mass movements, including recommendations for site-specific

interventions.

Collaborate with Multidisciplinary Teams: Communicate effectively with professionals across disciplines, contributing geological insights to multidisciplinary engineering and environmental design.

6708 000 000 78594 - 0 - FLOOD AND DROUGHT RISK MANAGEMENT	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
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**Ambito:**

B

Obiettivi: The objective of this course is to provide students with the understanding of the factors causing floods and droughts and with the knowledge both of the methods for quantifying and of the options for reducing such water risks. By the end of the course, students have the knowledge of the data requirement and methods used for the assessment of river flood and drought risk, in terms of hazard, exposure and vulnerability. Students will also learn about the measures available for mitigating and managing such risks (such as structures for flood defense, flood and drought policies/plans/mapping; forecasting and warning systems).

Applied skills: through the development of the assignments, students will apply their knowledge to obtain and process their own real-world meteo-hydrological data and to use them for i) computing meteorological and hydrological drought indicators and ii) estimating design floods.

Obiettivi inglese: The objective of this course is to provide students with the understanding of the factors causing floods and droughts and with the knowledge both of the methods for quantifying and of the options for reducing such water risks. By the end of the course, students have the knowledge of the data requirement and methods used for the assessment of river flood and drought risk, in terms of hazard, exposure and vulnerability.

Students will also learn about the measures available for mitigating and managing such risks (such as structures for flood defense, flood and drought policies/plans/mapping; forecasting and warning systems).

Applied skills: through the development of the assignments, students will apply their knowledge to obtain and process their own real-world meteo-hydrological data and to use them for i) computing meteorological and hydrological drought indicators and ii) estimating design floods.

6708 000 000 B5516 - 0 - GEOMATICS FOR GIS	ICAR/06	CEAR-04/A	6	48/0/0/0	No	Voto
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**Ambito:**

206 - Ingegneria civile

B

Obiettivi: Il corso approfondisce l'uso dei Sistemi Informativi Geografici (GIS) e le moderne tecnologie offerte dalla Geomatica per la raccolta, la gestione e l'analisi dei dati geospaziali. Gli studenti acquisiscono consapevolezza delle potenzialità e dei limiti delle tecniche di rappresentazione metrica del territorio o di specifiche infrastrutture, specialmente in termini di accuratezza e produttività, e apprendono come sceglierle ed integrarle per supportare diverse applicazioni dell'ingegneria ambientale e civile.

Obiettivi inglese: The course provides insights into the use of Geographical Information Systems (GIS) and the modern technologies offered by Geomatics to collect, manage and analyse geospatial data. Students gain awareness on potentials and limitations of the techniques for the metric representation of the landscape or of specific infrastructures, especially in terms of accuracy and productivity, and learn how to choose and integrate them to support different environmental and civil engineering applications.

6708 000 000 78593 - 0 - GROUNDWATER AND CONTAMINATION PROCESSES	ICAR/01	CEAR-01/A	6	48/0/0/0	No	Voto
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**Ambito:**

206 - Ingegneria civile

B

Obiettivi: The course provides fundamentals of subsurface flow and transport, emphasizing the primary role of groundwater in the hydrologic cycle, the relation of groundwater flow to hydrogeological properties, and the management of contaminated groundwater. Effective methods for the prediction and interpretation of groundwater processes will be discussed together with engineering implications.

These include basics of infrastructure design related to the subsurface environment. Particular attention will be reserved to well hydraulics having several implications in water exploitation, monitoring and remediation. Description and analysis of both synthetic and real case studies will provide the opportunity to jointly apply concepts and methods discussed during the course.

Obiettivi inglese: The course provides fundamentals of subsurface flow and transport, emphasizing the primary role of groundwater in the hydrologic cycle, the relation of groundwater flow to hydrogeological properties, and the management of contaminated groundwater. Effective methods for the prediction and interpretation of groundwater processes will be discussed together with engineering implications.

These include basics of infrastructure design related to the subsurface environment. Particular attention will be reserved to well hydraulics having several implications in water exploitation, monitoring and remediation. Description and analysis of both synthetic and real case studies will provide the opportunity to jointly apply concepts and methods discussed during the course.

6708 000 000 95813 - 0 - LARGE-SCALE WATER STRUCTURES	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
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**Ambito:**

B

Obiettivi: Students will learn advanced theoretical concepts and operational tools for the design of large-scale water structures, including dams, reservoirs and hydro-power systems. Students will gain expertise on the hydraulic and management challenges of large-scale water structures and their environmental impact. Students will be able to check dam stability, design key hydraulic facilities and large-scale hydro-power plants. Case studies related to recently built water structures will be examined.

Obiettivi inglese: Students will learn advanced theoretical concepts and operational tools for the design of large-scale water structures, including dams, reservoirs and hydro-power systems. Students will gain expertise on the hydraulic and management challenges of large-scale water structures and their environmental impact. Students will be able to check dam stability, design key hydraulic facilities and large-scale hydro-power plants. Case studies related to recently built water structures will be examined.

6708 000 000 72782 - 0 - MECHANICS OF HISTORICAL MASONRY STRUCTURES

ICAR/08

CEAR-06/A

6

48/0/0/0

No

Voto

**Ambito:**

B

Obiettivi: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to analyze historical masonry structures. Covering several historical periods, from the Roman Empire to modern times, the course places special emphasis on Gothic architecture, renowned for its integration of architectural and structural elements.

**Knowledge and Skills Development:**

- Knowledge: Students will gain a deep understanding of load-bearing mechanisms in masonry structures, including arches, vaults, domes, walls, and pillars. They will also learn about the common failures these structures face when subjected to horizontal (seismic) actions. In addition, students will explore key theories, including the principle of virtual works and the use of the rigid no tension model, simplifying the analysis of masonry materials.

- Skills: Through case studies, exercises, and the use of numerical tools (such as line of thrust calculations for arches), students will develop the ability to apply theoretical knowledge to real-world scenarios. They will also learn how to diagnose structural issues and propose effective interventions. Additionally, students will construct a comprehensive glossary of masonry terms and gain a detailed understanding of masonry typologies, which are critical for the Masonry Quality Index. The course also includes the possibility of visits to significant historical structures, such as churches, to further reinforce the practical understanding of masonry structures.

**Coherence with Program Objectives:**

This course is designed to complement the overall objectives of the Civil Engineering program by focusing on the structural analysis of historical buildings. It provides students with foundational skills that will be essential for advanced studies and professional work in structural engineering, conservation, and rehabilitation. The integration of theoretical knowledge and practical application ensures that students are prepared to handle complex structural problems in their future careers.

Obiettivi inglese: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to analyze historical masonry structures. Covering several historical periods, from the Roman Empire to modern times, the course places special emphasis on Gothic architecture, renowned for its integration of architectural and structural elements.

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6708 000 000 78965 - 0 - PUBLIC PROCUREMENT

IUS/10

GIUR-06/A

6

48/0/0/0

No

Voto

**Ambito:**

1008 - A scelta dello studente

D

Obiettivi: The aim of the course is to give a complete survey of the juridical and judicial landscape of the Italian and European systems in the topic of public procurement and contract.

Obiettivi inglese: The aim of the course is to give a complete survey of the juridical and judicial landscape of the Italian and European systems in the topic of public procurement and contract.

6708 000 000 78595 - 0 - ROAD SAFETY ENGINEERING

ICAR/04

CEAR-03/A

6

48/0/0/0

No

Voto

**Ambito:**

1008 - A scelta dello studente

D

Obiettivi: The objectives of the unit are to gain a clear understanding of:

- why road safety is important, how we can achieve improvements and who is doing the work;
- the multidisciplinary nature of road safety and why we need to use a combination of engineering, education and enforcement to be successful;
- the behaviour of road users and ways in which the road environment can be designed/improved to cater for their needs;
- the complexity of the human/vehicle/road system and how the interrelationships work to influence the level of safety;
- what are the legal responsibilities of road authorities and decision makers and how they can fulfil them;
- how to undertake accident investigations;
- how to collect accident data and what to look for in quality data;
- how to analyse accident data, turn it into information and develop cost effective, practical counter measures;
- what needs to be done after treating a site and how to do it;
- how to be proactive in preventing accidents before they occur.

Specific skill sets developed in the class are:

- Analysis of traffic collision and injury data;
- Analysis of collision risk in a road network (network screening);
- Identifying crash causal factors;
- Identifying and evaluating countermeasures;
- Principles of Road Safety Management.
- What is the Road safety Audit procedure, and what are aims and objectives, roles and responsibility; history of road safety audit, road safety audit and design standards, road safety audit tasks, various stages of safety audits; common identifiable problems.
- How to structure a road safety audit report, identify common problems.
- Case studies and site visit; what to look for on site visits.

Obiettivi inglese: The objectives of the unit are to gain a clear understanding of:

- why road safety is important, how we can achieve improvements and who is doing the work;
- the multidisciplinary nature of road safety and why we need to use a combination of engineering, education and enforcement to be successful;
- the behaviour of road users and ways in which the road environment can be designed/improved to cater for their needs;
- the complexity of the human/vehicle/road system and how the interrelationships work to influence the level of safety;
- what are the legal responsibilities of road authorities and decision makers and how they can fulfil them;
- how to undertake accident investigations;
- how to collect accident data and what to look for in quality data;
- how to analyse accident data, turn it into information and develop cost effective, practical counter measures;
- what needs to be done after treating a site and how to do it;
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- Analysis of collision risk in a road network (network screening);
- Identifying crash causal factors;
- Identifying and evaluating countermeasures;
- Principles of Road Safety Management.
- What is the Road safety Audit procedure, and what are aims and objectives, roles and responsibility; history of road safety audit, road safety audit and design standards, road safety audit tasks, various stages of safety audits; common identifiable problems.
- How to structure a road safety audit report, identify common problems.
- Case studies and site visit; what to look for on site visits.

6708 000 000 72807 - 0 - SCIENCE AND TECHNOLOGY OF COMPOSITE MATERIALS M	ING-IND/22	IMAT-01/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente						D
Obiettivi: Knowledge of properties, application and manufacturing technology of main composite materials. Comprehension of the mechanisms which allow to obtain particular properties on the basis of material components and their architecture. Ability in the choice of the most suitable composite material on the basis of the technological requirements of the product.						
Obiettivi inglese: Knowledge of properties, application and manufacturing technology of main composite materials. Comprehension of the mechanisms which allow to obtain particular properties on the basis of material components and their architecture. Ability in the choice of the most suitable composite material on the basis of the technological requirements of the product.						
6708 000 000 B6479 - 0 - SCIENCE OF CLIMATE CHANGE	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto

**Ambito:** 1008 - A scelta dello studente

Obiettivi: Students will learn what knowledge is needed to identify solutions to climate change mitigation and adaptation. They will learn how climate change can be mitigated, how adaptation may be carried out and how mitigation and adaptation interact each other. Students will learn what we know and what we still do not know about climate and climate change. They will also know what contribution they can give to resolve the climate challenge in both their roles of citizens and experts. The involved disciplines are: climate dynamics, climate analysis and modelling, geo-environmental sciences and water cycle, climate engineering and environmental engineering. The approach will be interdisciplinary with the aim to move to transdisciplinarity, namely, by setting the basis for an innovative scientific and technical approach.

Obiettivi inglese: Students will learn what knowledge is needed to identify solutions to climate change mitigation and adaptation. They will learn how climate change can be mitigated, how adaptation may be carried out and how mitigation and adaptation interact each other. Students will learn what we know and what we still do not know about climate and climate change. They will also know what contribution they can give to resolve the climate challenge in both their roles of citizens and experts. The involved disciplines are: climate dynamics, climate analysis and modelling, geo-environmental sciences and water cycle, climate engineering and environmental engineering. The approach will be interdisciplinary with the aim to move to transdisciplinarity, namely, by setting the basis for an innovative scientific and technical approach.

6708 000 000 B8644 - 0 - STRUCTURAL RELIABILITY	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
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**Ambito:** 206 - Ingegneria civile

B

**Obiettivi:** The student will acquire knowledge related to all aspects of structural reliability and conceptual structural design. The course will provide concepts to estimate the failure probability of structures and the structural behavior of complex buildings.

At the end of the course the student will be able to:

- master the basic principles of mathematical theory of probability applied to engineering
- estimate the uncertainties related to loads and strengths of structures
- master the basic principles of conceptual design of complex structures to predict their structural behavior
- estimate the uncertainties in structural behavior and its modelling
- calculate the reliability of simple structural systems
- understand the nature and origin of the current structural design code formats.

The course contributes to the objectives of the master's course related to structural design and natural risk management.

**Obiettivi inglese:** The student will acquire knowledge related to all aspects of structural reliability and conceptual structural design. The course will provide concepts to estimate the failure probability of structures and the structural behavior of complex buildings.

At the end of the course the student will be able to:

- master the basic principles of mathematical theory of probability applied to engineering
- estimate the uncertainties related to loads and strengths of structures
- master the basic principles of conceptual design of complex structures to predict their structural behavior
- estimate the uncertainties in structural behavior and its modelling
- calculate the reliability of simple structural systems
- understand the nature and origin of the current structural design code formats.

The course contributes to the objectives of the master's course related to structural design and natural risk management.

6708 000 000 72789 - 0 - STRUCTURAL STRENGTHENING & REHABILITATION	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
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**Ambito:**

B

**Obiettivi:** The course Structural Strengthening and Rehabilitation aims to give students a real structural design ability in many different areas through many different techniques. The course focuses on all materials present in existing structures like masonry, concrete, steel and timber. It includes various information and annotations on non-destructive testing of materials and evaluation of damage levels in historic structures, presenting them in the framework of Mohr-Coulomb materials.

The strengthening and rehabilitation design is developed by using traditional and innovative techniques. Among them, the case of restoration with fibre-reinforced polymers is discussed in detail, presenting both the theoretical basis and the design rules, with applications to many important examples.

The course discusses several relevant cases of structural damage in detail: soil settlement, earthquake, fire, corrosion, and shock. Some cases of problem solutions are discussed in detail, by comparing the different strengthening techniques.

The analysis is mainly worked out with hand calculation so that students can widen their design capacity by applying themselves to some homework proposed at the end of the course, without the need for complex structural analysis programs.

The course is expected to form students for real professional strengthening activities, giving them the ability to investigate the damage severity and select the most appropriate strengthening technique.

**Obiettivi inglese:** The course Structural Strengthening and Rehabilitation aims to give students a real structural design ability in many different areas through many different techniques. The course focuses on all materials present in existing structures like masonry, concrete, steel and timber. It includes various information and annotations on non-destructive testing of materials and evaluation of damage levels in historic structures, presenting them in the framework of Mohr-Coulomb materials.

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The course discusses several relevant cases of structural damage in detail: soil settlement, earthquake, fire, corrosion, and shock. Some cases of problem solutions are discussed in detail, by comparing the different strengthening techniques.

The analysis is mainly worked out with hand calculation so that students can widen their design capacity by applying themselves to some homework proposed at the end of the course, without the need for complex structural analysis programs.

The course is expected to form students for real professional strengthening activities, giving them the ability to investigate the damage severity and select the most appropriate strengthening technique.

6708 000 000 72748 - 0 - SUSTAINABILITY IN CONSTRUCTION

ICAR/09

CEAR-07/A

6

48/0/0/0

No

Voto

**Ambito:** 206 - Ingegneria civile

B

Obiettivi: Course overview, introduction to sustainability. Definitions, trends, measurements. Aspects on sustainability (environmental, economic, social). Environmental footprint of engineered systems, with emphasis on civil engineering (energy consumptions, CO2 emissions, etc).

Performance-based design and life-cycle planning. The various aspects to be considered for sustainability in construction: material's production and transformation, management of construction process, occupancy (use costs energy and cost consumptions), occupancy (maintenance and durability issues), end-of-life costs, reuse/recycling. Life-cycle analysis (LCA): Cradle-to-grave analysis, LCA as a min-max problem. Mathematical tools required (Optimization techniques, multi-criteria decision making methods, simulation methods, statistics). Social Life Cycle Assessment (S-LCA) and Ecologically based LCA (Eco-LCA). Safety as a prerequisite. Energy efficiency in buildings. Renewable energy with emphasis to building applications (solar thermal and photovoltaic energy, geothermal energy). Protocols for rating systems for the design, construction and operation of high performance green buildings (LEED system, Ithaca).

Obiettivi inglese: Course overview, introduction to sustainability. Definitions, trends, measurements. Aspects on sustainability (environmental, economic, social). Environmental footprint of engineered systems, with emphasis on civil engineering (energy consumptions, CO2 emissions, etc).

Performance-based design and life-cycle planning. The various aspects to be considered for sustainability in construction: material's production and transformation, management of construction process, occupancy (use costs energy and cost consumptions), occupancy (maintenance and durability issues), end-of-life costs, reuse/recycling. Life-cycle analysis (LCA): Cradle-to-grave analysis, LCA as a min-max problem. Mathematical tools required (Optimization techniques, multi-criteria decision making methods, simulation methods, statistics). Social Life Cycle Assessment (S-LCA) and Ecologically based LCA (Eco-LCA). Safety as a prerequisite. Energy efficiency in buildings. Renewable energy with emphasis to building applications (solar thermal and photovoltaic energy, geothermal energy). Protocols for rating systems for the design, construction and operation of high performance green buildings (LEED system, Ithaca).

6708 000 000 81509 - 0 - SUSTAINABLE ROAD INFRASTRUCTURES

ICAR/04

CEAR-03/A

6

48/0/0/0

No

Voto

**Ambito:**

B

Obiettivi: Students will be introduced to road engineering and learn how these transportation infrastructures are conceived. A range of different externalities will be addressed and evaluated in order to identify the possible sustainable approaches towards the design and construction of less impacting roads. Emerging topics such as territory fragmentation and soil-bio engineering will be imparted as possible multidisciplinary solutions for the novel civil engineer that will know how to evaluate the impact of a road infrastructure on the territory and how to design the interventions to mitigate these effects, for a more sustainable infrastructure.

Obiettivi inglese: Students will be introduced to road engineering and learn how these transportation infrastructures are conceived. A range of different externalities will be addressed and evaluated in order to identify the possible sustainable approaches towards the design and construction of less impacting roads. Emerging topics such as territory fragmentation and soil-bio engineering will be imparted as possible multidisciplinary solutions for the novel civil engineer that will know how to evaluate the impact of a road infrastructure on the territory and how to design the interventions to mitigate these effects, for a more sustainable infrastructure.

**Anno Accademico** 2026/2027  
**Classe** LM-23 R-INGEGNERIA CIVILE  
**Corso** 6708-CIVIL ENGINEERING

**Curriculum: CLIMATE CHANGE ADAPTATION (B66)**

### Primo Anno di Corso

**Gruppo: 1) Mandatory courses**

**TAF: Ambito:**

**Cfu min: Cfu max:**

Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6708 000 000 72756 - 0 - ADVANCED DESIGN OF STRUCTURES		ICAR/09	CEAR-07/A		9	72/0/0/0	No	Voto

**Ambito:** 206 - Ingegneria civile

**Obiettivi:** Students will gain in-depth knowledge of the structural behavior of reinforced concrete (Module 1), prestressed concrete, steel, and composite structures (Module 2). They will introduced to advanced concepts and methods for the verification, modeling, and design of these structures, covering topics such as: failure and serviceability limit states, the role of ductility at both sectional and structural levels, longterm effects (including concrete creep, shrinkage, and steel relaxation), the effects of precompression on RC elements, plates under transverse loads, cylindrical shells and tanks, bracing systems, built-up steel columns, buckling issues, and stud bolt connectors in composite beams.

By the end of the course, students will be able to develop preliminary design and verifications of steel and RC structures (frames and plates), both in terms of ultimate and serviceability limit states; they could also determine the amount of reinforcement and draw the most important structural details. They will be also equipped to independently tackle the preliminary design of cylindrical tanks and prestressed beams. Reference will be made to European standards.

**Obiettivi inglese:** Students will gain in-depth knowledge of the structural behavior of reinforced concrete (Module 1), prestressed concrete, steel, and composite structures (Module 2). They will introduced to advanced concepts and methods for the verification, modeling, and design of these structures, covering topics such as: failure and serviceability limit states, the role of ductility at both sectional and structural levels, longterm effects (including concrete creep, shrinkage, and steel relaxation), the effects of precompression on RC elements, plates under transverse loads, cylindrical shells and tanks, bracing systems, built-up steel columns, buckling issues, and stud bolt connectors in composite beams.

By the end of the course, students will be able to develop preliminary design and verifications of steel and RC structures (frames and plates), both in terms of ultimate and serviceability limit states; they could also determine the amount of reinforcement and draw the most important structural details. They will be also equipped to independently tackle the preliminary design of cylindrical tanks and prestressed beams. Reference will be made to European standards.

6708 000 000 72757 - 0 - ADVANCED HYDROSYSTEMS ENGINEERING	ICAR/02	CEAR-01/B	9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: 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.</p> <p>Obiettivi inglese: 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.</p>						
6708 000 000 72758 - 0 - ADVANCED STRUCTURAL MECHANICS	ICAR/08	CEAR-06/A	9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance students' understanding of structural behavior and enhance their ability to apply structural analysis methods to civil engineering structures. Students will acquire knowledge in the following areas: Structural Matrix Analysis, i.e., techniques for analyzing 2D truss and frame structures using the Direct Stiffness Method and FEM software. Buckling Analysis, i.e., methods for buckling and post-buckling analysis of discrete and continuous systems, with FEM applications. Plastic Analysis, i.e., concepts of plasticity, incremental and limit analysis for truss and beam systems, also using FEM tools. The main skills developed during this course include: Proficiency in matrix analysis and the Finite Element Method (FEM) for analyzing truss and frame structures. Ability to evaluate buckling and post-buckling behavior of rigid and continuous systems, using equilibrium and energy methods. Competence in conducting plastic analysis of structural systems, including an understanding of plastic hinges. Software Proficiency: hands-on experience with FEM-based software for solving structural, buckling, and elasto-plastic problems. Analytical and critical thinking: enhanced ability to approach complex structural issues with theoretical and computational tools. The course contributes to the objectives of the master's program related to the application of mathematical tools for interpreting, describing, and modeling structural problems.</p> <p>Obiettivi inglese: The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance students' understanding of structural behavior and enhance their ability to apply structural analysis methods to civil engineering structures. Students will acquire knowledge in the following areas: Structural Matrix Analysis, i.e., techniques for analyzing 2D truss and frame structures using the Direct Stiffness Method and FEM software. Buckling Analysis, i.e., methods for buckling and post-buckling analysis of discrete and continuous systems, with FEM applications. Plastic Analysis, i.e., concepts of plasticity, incremental and limit analysis for truss and beam systems, also using FEM tools. The main skills developed during this course include: Proficiency in matrix analysis and the Finite Element Method (FEM) for analyzing truss and frame structures. Ability to evaluate buckling and post-buckling behavior of rigid and continuous systems, using equilibrium and energy methods. Competence in conducting plastic analysis of structural systems, including an understanding of plastic hinges. Software Proficiency: hands-on experience with FEM-based software for solving structural, buckling, and elasto-plastic problems. Analytical and critical thinking: enhanced ability to approach complex structural issues with theoretical and computational tools. The course contributes to the objectives of the master's program related to the application of mathematical tools for interpreting, describing, and modeling structural problems.</p>						
6708 000 000 72765 - 0 - GEOTECHNICAL ENGINEERING	ICAR/07	CEAR-05/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: The course aims to provide students with in-depth knowledge and practical skills in advanced soil mechanics and geotechnical modeling, focusing on applications in civil engineering design. By the end of the course, students will have gained a comprehensive understanding of the fundamental and advanced principles of soil behavior under various loading conditions, which are essential for assessing soil-structure interaction. They will acquire knowledge of geotechnical characterization methods, applicable both in laboratory and in situ, aligning with the program's objective to prepare students for design, construction, and stability assessments in civil engineering. In terms of skills, students will be proficient in evaluating and comparing key physical and mechanical soil parameters through experimental testing, integrating techniques from soil mechanics for geotechnical assessments. They will also be capable of applying geotechnical models for the design and stability analysis of primary geotechnical structures, in line with the CdS's emphasis on operational and methodological expertise in civil structure and infrastructure projects. Furthermore, students will develop the competence to conduct analyses of foundation and retaining structure stability, including complex soil behaviors and ensuring reliable, safety-oriented designs.</p> <p>Obiettivi inglese: The course aims to provide students with in-depth knowledge and practical skills in advanced soil mechanics and geotechnical modeling, focusing on applications in civil engineering design. By the end of the course, students will have gained a comprehensive understanding of the fundamental and advanced principles of soil behavior under various loading conditions, which are essential for assessing soil-structure interaction. They will acquire knowledge of geotechnical characterization methods, applicable both in laboratory and in situ, aligning with the program's objective to prepare students for design, construction, and stability assessments in civil engineering. In terms of skills, students will be proficient in evaluating and comparing key physical and mechanical soil parameters through experimental testing, integrating techniques from soil mechanics for geotechnical assessments. They will also be capable of applying geotechnical models for the design and stability analysis of primary geotechnical structures, in line with the CdS's emphasis on operational and methodological expertise in civil structure and infrastructure projects. Furthermore, students will develop the competence to conduct analyses of foundation and retaining structure stability, including complex soil behaviors and ensuring reliable, safety-oriented designs.</p>						

6708 000 000 72764 - 0 - NUMERICAL METHODS

MAT/08

MATH-05/A

12

96/0/0/0

No

Voto

**Ambito:** 2019 - Attività formative affini o integrative

C

Obiettivi: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to recognize, analyze and solve numerically on the computer some classes of mathematical problems naturally arising from modelling of physical systems subject to simulation/design in civil engineering.

Students will acquire knowledge in the following areas: (1) fundamentals of numerical analysis, such as types of numerical errors, machine numbers, posedness and conditioning of mathematical problems, convergence, stability, accuracy and (spatial and temporal) efficiency of numerical methods; (2) numerical solution of systems of linear equations; (3) numerical solution of non-linear equations and systems of non-linear equations; (4) numerical interpolation and approximation (fitting) of data and functions; (5) numerical differentiation and integration (quadrature) of functions; (6) numerical solution of (linear) differential equations of elliptic, parabolic and hyperbolic type, with focus on the finite difference method and some mention of the finite element method.

The main skills developed during this course include: (1) proficiency in recognizing classes of mathematical problems, analyzing them from posedness and conditioning point of views and, hence, predicting the difficulty of their numerical solution; (2) ability to choose the numerical method suitable for the solution of some classes of mathematical problems in accordance with the desired accuracy-efficiency tradeoff; (3) software competence: hands-on experience with using Matlab software and its programming language to implement algorithms and, in particular, numerical methods; (4) analytical and critical thinking: enhanced ability both to figure out the numerical algorithms running at the core of widely used simulation /design softwares in civil engineering, and to interpret their outputs from the numerical perspective.

The course contributes to the objectives of the master's program by completing and complementing the theoretical mathematical preparation acquired by students during the bachelor's degree with the knowledge and ability to solve numerically (on the computer) classes of mathematical problems of interest to civil engineering.

Obiettivi inglese: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to recognize, analyze and solve numerically on the computer some classes of mathematical problems naturally arising from modelling of physical systems subject to simulation/design in civil engineering.

Students will acquire knowledge in the following areas: (1) fundamentals of numerical analysis, such as types of numerical errors, machine numbers, posedness and conditioning of mathematical problems, convergence, stability, accuracy and (spatial and temporal) efficiency of numerical methods; (2) numerical solution of systems of linear equations; (3) numerical solution of non-linear equations and systems of non-linear equations; (4) numerical interpolation and approximation (fitting) of data and functions; (5) numerical differentiation and integration (quadrature) of functions; (6) numerical solution of (linear) differential equations of elliptic, parabolic and hyperbolic type, with focus on the finite difference method and some mention of the finite element method.

The main skills developed during this course include: (1) proficiency in recognizing classes of mathematical problems, analyzing them from posedness and conditioning point of views and, hence, predicting the difficulty of their numerical solution; (2) ability to choose the numerical method suitable for the solution of some classes of mathematical problems in accordance with the desired accuracy-efficiency tradeoff; (3) software competence: hands-on experience with using Matlab software and its programming language to implement algorithms and, in particular, numerical methods; (4) analytical and critical thinking: enhanced ability both to figure out the numerical algorithms running at the core of widely used simulation /design softwares in civil engineering, and to interpret their outputs from the numerical perspective.

The course contributes to the objectives of the master's program by completing and complementing the theoretical mathematical preparation acquired by students during the bachelor's degree with the knowledge and ability to solve numerically (on the computer) classes of mathematical problems of interest to civil engineering.

6708 000 000 95714 - 0 - SUSTAINABLE TRANSPORT SYSTEM DESIGN

ICAR/05

CEAR-03/B

9

72/0/0/0

No

Voto

**Ambito:** 206 - Ingegneria civile

B

Obiettivi: The course of Sustainable Transport System Design is split into two modules: the Sustainable Transportation Engineering module covers the basic elements of transportation systems engineering with reference to sustainable transport modelling and planning, while the Urban road mobility design and maintenance module focuses on the design of infrastructure to improve the sustainability of transport systems. The objective of the "Sustainable Transportation Engineering" module is to provide students with knowledge on sustainable transport planning framework. The module delves into supply- and demand-oriented methods and policies aimed at improving the environmental efficiency of transport systems. Students will learn theoretical and practical skills to model and simulate users' behaviour and transport systems performances and impacts, also in the context of new transportation technologies.

Obiettivi inglese: The course of Sustainable Transport System Design is split into two modules: the Sustainable Transportation Engineering module covers the basic elements of transportation systems engineering with reference to sustainable transport modelling and planning, while the Urban road mobility design and maintenance module focuses on the design of infrastructure to improve the sustainability of transport systems. The

objective of the "Sustainable Transportation Engineering" module is to provide students with knowledge on sustainable transport planning framework. The module delves into supply- and demand-oriented methods and policies aimed at improving the environmental efficiency of transport systems. Students will learn theoretical and practical skills to model and simulate users' behaviour and transport systems performances and impacts, also in the context of new transportation technologies.

**Gruppo: 2) Elective courses****TAF: F Ambito: 1147 - Altre conoscenze utili per****Cfu min: 6 Cfu max: 6**

Note: Choose 6 credits among the following courses:

**Attività formativa****TIP****SSD****SSD 2024****TAF****CFU****ORE F/E/L/N****FREQ. VER.**

6708 000 000 B8640 - 0 - ROAD AND TRANSPORTATION ENGINEERING DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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**Ambito:** 0000 - Nessun Ambito

F

**Obiettivi:** Students attending the course will develop the design of a road infrastructure, acquiring knowledge about the specific design standards and procedures. In particular the course will focus on the construction of a roundabout instead of an intersection in a real urban context. The student will obtain the skills necessary to design a roundabout in terms of pavement design, geometry and road signs. Interaction and collaboration between students will be fostered through the group work on the project.

**Obiettivi inglese:** Students attending the course will develop the design of a road infrastructure, acquiring knowledge about the specific design standards and procedures. In particular the course will focus on the construction of a roundabout instead of an intersection in a real urban context. The student will obtain the skills necessary to design a roundabout in terms of pavement design, geometry and road signs. Interaction and collaboration between students will be fostered through the group work on the project.

6708 000 000 B8638 - 0 - STRUCTURAL ENGINEERING DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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**Ambito:** 0000 - Nessun Ambito

F

**Obiettivi:** Students attending the course will delve into the study of the topics concerning the design of civil structures, acquiring knowledge about the specific design standards and procedures. Basic theoretical concepts, covered in other courses, will be recalled with the objective of applying them for the development of a project, regarding the design of a reinforced concrete building under static loading conditions. Students will also learn the use of a finite element software for the structural analysis and will develop blueprints using a CAD software. Interaction and collaboration between students will be fostered through the group work on the project.

**Obiettivi inglese:** Students attending the course will delve into the study of the topics concerning the design of civil structures, acquiring knowledge about the specific design standards and procedures. Basic theoretical concepts, covered in other courses, will be recalled with the objective of applying them for the development of a project, regarding the design of a reinforced concrete building under static loading conditions. Students will also learn the use of a finite element software for the structural analysis and will develop blueprints using a CAD software. Interaction and collaboration between students will be fostered through the group work on the project.

6708 000 000 B8639 - 0 - WATER ENGINEERING AND CLIMATE CHANGE ADAPTATION DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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PROJECTS

F

**Ambito:** Students attending the course will delve into water engineering design projects. Students will acquire knowledge on standards and procedures towards resilient design solutions under changing climatic and socioeconomic conditions. Students will learn the use of open source softwares to analyse the water cycle and related hydraulic problems. Interaction and collaboration between students will be fostered through group activities during classes.

**Obiettivi inglese:** Students attending the course will delve into water engineering design projects. Students will acquire knowledge on standards and procedures towards resilient design solutions under changing climatic and socioeconomic conditions. Students will learn the use of open source softwares to analyse the water cycle and related hydraulic problems. Interaction and collaboration between students will be fostered through group activities during classes.

## Secondo Anno di Corso

### Gruppo: 1) Mandatory courses

**TAF:** Ambito:

**Cfu min:** Cfu max:

Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 B5607 - 0 - ACTIONS ON STRUCTURES AND INFRASTRUCTURES IN A CHANGING CLIMATE	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
			B			
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p><b>Obiettivi:</b> Gli studenti apprenderanno metodi per la progettazione ingegneristica in presenza di cambiamento climatico, ovvero non stazionarietà nei processi dinamici che determinano le forzanti su strutture e infrastrutture. Nel dettaglio, verranno presi in considerazione modelli non stazionari di data analysis e modelli deterministici transizionali per la simulazione di eventi climatici e meteorologici estremi, con particolare attenzione alle aree costiere dove vive circa il 40% della popolazione mondiale. In particolare le lezioni si concentreranno su: (1) stima dei valori estremi e dell'intera dinamica delle forzanti utilizzando: (a) modelli deterministici per strutture e infrastrutture selezionate, che utilizzeranno variabili in ingresso derivate da scenari climatici per diverse ipotesi di emissioni future; (b) metodi di data analysis, machine learning e deep learning con struttura e parametri variabili nel tempo. (2) Integrazione di modelli fisici e tecniche di assimilazione dei dati per la progettazione ingegneristica in presenza di cambiamenti climatici, con un approccio di minimizzazione d'incertezza. (3) Valutazione delle proprietà statistiche e fisiche del clima, del contesto socio-economico e delle strutture che possono portare alla combinazione di rischi climatici e conseguente amplificazione delle forzanti (eventi di tipo "black swan"). Il percorso di formazione sarà improntato alla discussione, valutazione d'utilizzo dei risultati più recenti della ricerca.</p> <p><b>Obiettivi inglese:</b> Students will learn methods for engineering design in the presence of a changing climate, that induces non-stationarity in the dynamic processes determining forcings over structures and infrastructures. In detail, non-stationary data-based models and deterministic transient models for the simulation of climatic and weather extremes will be considered, with a specific focus on the coastal areas where about 40% of humans live. Topics will include: (1) extreme values and overall regime estimation of actions by using: (a) deterministic models of forcings dynamics for selected structures and infrastructures, which will be fed by a changing climate for different scenarios of future emissions; (b) data-based, machine learning and deep learning methods with time varying structure and parameters. (2) Integration of physically-based models and data assimilation for engineering design under climate change, with an uncertainty minimization approach. (3) Evaluation of statistical and physical properties of climate, society and structures which may lead to combination of climate risks and unpredictable amplification of climate forcings and climate change impact (black swan events). Focus will be made on the most recent research outcomes.</p>						
6708 000 000 B5605 - 0 - CLIMATE CHANGE MODELLING, MITIGATION AND ADAPTATION	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
			B			
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p><b>Obiettivi:</b> Gli studenti apprenderanno tecniche di generazione di scenari climatici e meteorologici futuri che potranno essere utilizzati per supportare la progettazione di strutture e infrastrutture civili esposte all'impatto dei cambiamenti climatici. Inoltre, verranno esaminate soluzioni di ingegneria civile per la mitigazione e l'adattamento ai cambiamenti climatici, concentrandosi su energie rinnovabili, gestione dei rischi climatici con metodologie a basse emissioni di carbonio e strategie e interventi innovativi per la riduzione della pericolosità associata ad eventi estremi. L'analisi di rischio e la teoria delle decisioni saranno oggetto di considerazione quali mezzi efficaci e trasparenti per assegnare priorità di intervento ed impostare la comunicazione con portatori di interesse, con il supporto di metodi avanzati per la valutazione d'incertezza. L'analisi e la modellazione congiunta di soluzioni e sistemi sociali sarà il concetto guida del corso, con un percorso didattico in evoluzione che si concentrerà sugli sviluppi più recenti della ricerca e farà uso di informazioni ad accesso libero.</p> <p><b>Obiettivi inglese:</b> Students of this course will learn how to generate future climatic and weather scenarios that may be used to support the design of civil structures and infrastructures that are exposed to the impact of climate change. Furthermore, civil engineering solutions for climate change mitigation and adaptation will be examined, by focusing on renewable energy, low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design and a successful communication with stakeholders. The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent research developments and will make use of open access information.</p>						
6708 000 000 B5606 - 0 - LABORATORY OF CLIMATE CHANGE ADAPTATION			3	0/0/24/0	No	Voto
			F			
<p><b>Ambito:</b> 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro</p> <p><b>Obiettivi:</b> e locale e su scala temporale fine, stimare i cambiamenti climatici e la loro variabilità spaziale. Verranno prese in considerazione diverse variabili climatiche, concentrandosi sulle loro caratteristiche fisiche e statistiche e sull'affidabilità delle rispettive simulazioni.</p> <p><b>Obiettivi inglese:</b> Students will learn how to obtain publicly available past and future climatic scenarios, test their validity with the support of data visualization and make their evidence-based assessment for uncertainty estimation. Open source software will be used to download and analyse the output from global climate models, downscale the data at local spatial scale and fine time scale, detect climate change and its spatial variability. Several climatic variables will be considered by focusing on their physical and statistical behaviours and the reliability of their simulations.</p>						
6708 000 000 B8637 - 0 - SEMINARI IN LINGUA ITALIANA SULL'INGEGNERIA CIVILE			3	0/0/24/0	No	Giudizio
			F			
<p><b>Ambito:</b> 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro</p> <p><b>Obiettivi:</b> Course provides an updated overview of technological innovations in Civil Engineering, promotes understanding of environmental and sustainability challenges, encourages multidisciplinary collaboration and contributes to developing practical and applied skills, offering students the opportunity to develop hands-on skills through case studies workshops that allow them to apply theoretical concepts to real-world and contemporary scenarios. Furthermore the course promotes skills relates to the proficient use of technical language in Italian.</p> <p><b>Obiettivi inglese:</b> Course provides an updated overview of technological innovations in Civil Engineering, promotes understanding of environmental and sustainability challenges, encourages multidisciplinary collaboration and contributes to developing practical and applied skills, offering students the opportunity to</p>						

develop hands-on skills through case studies workshops that allow them to apply theoretical concepts to real-world and contemporary scenarios. Furthermore the course promotes skills relates to the proficient use of technical language in Italian.

**Gruppo: 2) Elective courses****TAF: Ambito:****Cfu min: 15 Cfu max: 15**

Note: Choose one of the two following groups:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
2.1) Structural engineering					0-15			
6708 000 000 B5609 - 0 - ADVANCED DESIGN OF MARINE STRUCTURES		ICAR/09	CEAR-07/A		3	24/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile				B				
<p>Obiettivi: Students will acquire knowledge related to the practical skills concerning advanced analysis methods and design tools adopted for marine structures. Relevant topics will include practical applications of criteria and approaches for the structural analysis, of requirements and design protocols for the structural design of marine structures, including instability verification, advanced fatigue methods, requirements against seismic actions and exceptional loadings. The topics will be mainly presented through case studies, exercises and direct application by the students. At the end of the course the students will be able to develop structural analysis and practical design of marine structures.</p> <p>The course contributes to the objectives of the master's course related to structural design and natural risk management.</p> <p>Obiettivi inglese: Students will acquire knowledge related to the practical skills concerning advanced analysis methods and design tools adopted for marine structures. Relevant topics will include practical applications of criteria and approaches for the structural analysis, of requirements and design protocols for the structural design of marine structures, including instability verification, advanced fatigue methods, requirements against seismic actions and exceptional loadings. The topics will be mainly presented through case studies, exercises and direct application by the students. At the end of the course the students will be able to develop structural analysis and practical design of marine structures.</p> <p>The course contributes to the objectives of the master's course related to structural design and natural risk management.</p>								
6708 000 000 B5608 - 0 - ANALYSIS AND MODELLING OF MARINE STRUCTURES		ICAR/08	CEAR-06/A		6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile				B				
<p>Obiettivi: The course focuses on the fundamental principles of structural dynamics and fatigue analysis applied to marine structures. Students will explore the behavior of offshore and coastal constructions under various environmental loads, utilizing finite element modeling techniques to analyze stress responses, durability, and performance over time. Key topics include load assessment, structural response modeling, and techniques for predicting and mitigating fatigue in marine environments. Through hands-on applications and simulations, students gain practical skills in applying advanced modeling tools to enhance the reliability and safety of marine infrastructures.</p> <p>Obiettivi inglese: The course focuses on the fundamental principles of structural dynamics and fatigue analysis applied to marine structures. Students will explore the behavior of offshore and coastal constructions under various environmental loads, utilizing finite element modeling techniques to analyze stress responses, durability, and performance over time. Key topics include load assessment, structural response modeling, and techniques for predicting and mitigating fatigue in marine environments. Through hands-on applications and simulations, students gain practical skills in applying advanced modeling tools to enhance the reliability and safety of marine infrastructures.</p>								
6708 000 000 B5610 - 0 - DESIGN OF MARINE STRUCTURES		ICAR/09	CEAR-07/A		6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile				B				
<p>Obiettivi: The student will acquire knowledge related to the structural design of the main typologies of marine structures, with respect to conceptual, formal and operational aspects. Relevance will be done both at off-shore and harbor structures. At the end of the course the students will be able to evaluate the mechanical behavior of marine structures, to develop the fundamental stages of the design process and structural analysis, including a proper choice of the building materials. The course contributes to the objectives of the master's course related to structural design and natural risk management.</p> <p>Obiettivi inglese: The student will acquire knowledge related to the structural design of the main typologies of marine structures, with respect to conceptual, formal and operational aspects. Relevance will be done both at off-shore and harbor structures. At the end of the course the students will be able to evaluate the mechanical behavior of marine structures, to develop the fundamental stages of the design process and structural analysis, including a proper choice of the building materials. The course contributes to the objectives of the master's course related to structural design and natural risk management.</p>								

## 2.2) Coastal engineering

0-15

6708 000 000 B5612 - 0 - ENVIRONMENTAL PERSPECTIVES FOR MULTIMODAL TRANSPORT OPERATIONS

ICAR/05

CEAR-03/B

6

48/0/0/0

No

Voto

B

**Ambito:** 206 - Ingegneria civile

Obiettivi: The course aims at studying intermodal systems for the transportation of goods and of their performance, which is the consequence of the interactions between the different components - both operational and infrastructural.

The course aims at training engineers capable of tackling and solving problems in complex systems, with multidisciplinary skills and approaches. Students will acquire a solid preparation in the field of transportation systems engineering for the planning of activities in freight transportation nodes and for the management of freight and commodity flows.

Topics to be covered are methods and models of design, planning, evaluation of the performance and impacts of operations relating to freight transportation, optimization of freight transportation operations according to criteria of environmental sustainability and economic efficiency, in a systemic approach.

The main objectives are: 1) Ability to design and plan transportation systems from a systemic perspective and with a modelling and multidisciplinary approach in a changing context. 2) Ability to identify advantages and limits of applicability of scenarios and design solutions, with particular reference to the availability of resources and the effects of the intervention. 3) Ability to address the issues of transport systems engineering on a professional level, as well as to understand the link between transport systems, energy sources, infrastructures and territory.

Obiettivi inglese: The course aims at studying intermodal systems for the transportation of goods and of their performance, which is the consequence of the interactions between the different components - both operational and infrastructural.

The course aims at training engineers capable of tackling and solving problems in complex systems, with multidisciplinary skills and approaches. Students will acquire a solid preparation in the field of transportation systems engineering for the planning of activities in freight transportation nodes and for the management of freight and commodity flows.

Topics to be covered are methods and models of design, planning, evaluation of the performance and impacts of operations relating to freight transportation, optimization of freight transportation operations according to criteria of environmental sustainability and economic efficiency, in a systemic approach.

The main objectives are: 1) Ability to design and plan transportation systems from a systemic perspective and with a modelling and multidisciplinary approach in a changing context. 2) Ability to identify advantages and limits of applicability of scenarios and design solutions, with particular reference to the availability of resources and the effects of the intervention. 3) Ability to address the issues of transport systems engineering on a professional level, as well as to understand the link between transport systems, energy sources, infrastructures and territory.

6708 000 000 B5611 - 0 - GEOTECHNICAL DESIGN OF COASTAL INFRASTRUCTURES

ICAR/07

CEAR-05/A

3

24/0/0/0

No

Voto

B

**Ambito:** 206 - Ingegneria civile

Obiettivi: Il corso presenta una prospettiva geomeccanica sui processi che caratterizzano le zone costiere e la loro evoluzione nonché sul progetto di infrastrutture costiere, sul loro monitoraggio e valutazione del rischio

Obiettivi inglese: The course offers a geomechanical perspective on nearshore processes and shoreline evolution, coastal infrastructure design, monitoring and risk assessment, in the context of a changing climate.

At the end of the course the students will be able to develop a suitable geotechnical model based on site characterisation and field measurements. The students will also tackle the analysis of geotechnical solutions that aim at mitigating the coastal erosion and providing protection against the sea level rise.

6708 000 000 78724 - 0 - OCEAN AND COASTAL ENGINEERING

ICAR/01

CEAR-01/A

6

48/0/0/0

No

Voto

B

**Ambito:** 206 - Ingegneria civile

Obiettivi: Al termine dell'insegnamento gli studenti saranno in grado di condurre una caratterizzazione di base dell'ambiente marino (livello di mare, onde, correnti e vento) e di stimare le condizioni climatiche, le azioni marine e le condizioni di progetto su strutture offshore e costiere.

Obiettivi inglese: The student at the end of the course is able to perform basic characterization of the ocean environment (sea water level, sea waves, currents and wind) and to estimate the climate and design conditions and sea actions on the offshore and coastal structures.

**Gruppo: 3) Final examination****TAF: Ambito:****Cfu min: 15 Cfu max: 15**

Note: Students can choose only the "Final examination" (Group A) or the "Final examination" and one of the learning activities among "Internship for preparation for the final examination", "Internship abroad for preparation for the final examination" or "Preparation for the final examination abroad" (Group B).

**Attività formativa****TIP****SSD****SSD 2024****TAF****CFU****ORE F/E/L/N****FREQ. VER.**

3.1) Group A		0-15			
6708 000 000 60750 - 0 - FINAL EXAMINATION		15	0/0/0/0	No	
Ambito:	1018 - Per la prova finale	E			
Obiettivi: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
3.2) Group B		0-15			
6708 000 000 86301 - 0 - FINAL EXAMINATION		3	0/0/0/0	No	
Ambito:	1018 - Per la prova finale	E			
Obiettivi: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
6708 000 000 84551 - 1 - INTERNSHIP ABROAD FOR PREPARATION OF THE FINAL EXAMINATION		12	0/0/300/0	No	Giudizio
Ambito:	1018 - Per la prova finale	E			
Obiettivi: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.					
Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.					
6708 000 000 86296 - 1 - INTERNSHIP FOR PREPARATION FOR THE FINAL EXAMINATION		12	0/0/300/0	No	Giudizio
Ambito:	1018 - Per la prova finale	E			
Obiettivi: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.					
Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.					
6708 000 000 84548 - 1 - PREPARATION FOR THE FINAL EXAMINATION ABROAD		12	0/0/300/0	No	Giudizio
Ambito:	1018 - Per la prova finale	E			
Obiettivi: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.					
Obiettivi inglese: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.					

**Gruppo: 4) Courses freely chosen by the student****TAF: D Ambito: 1008 - A scelta dello studente****Cfu min: 12 Cfu max: 12**

Note: Choose 12 credits. The course board suggests to attend to the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 B5609 - 0 - ADVANCED DESIGN OF MARINE STRUCTURES	ICAR/09	CEAR-07/A	3	24/0/0/0	No	Voto
B						
<p><b>Ambito:</b>            Obiettivi: Students will acquire knowledge related to the practical skills concerning advanced analysis methods and design tools adopted for marine structures. Relevant topics will include practical applications of criteria and approaches for the structural analysis, of requirements and design protocols for the structural design of marine structures, including instability verification, advanced fatigue methods, requirements against seismic actions and exceptional loadings. The topics will be mainly presented through case studies, exercises and direct application by the students. At the end of the course the students will be able to develop structural analysis and practical design of marine structures.            The course contributes to the objectives of the master's course related to structural design and natural risk management.</p> <p><b>Obiettivi inglese:</b> Students will acquire knowledge related to the practical skills concerning advanced analysis methods and design tools adopted for marine structures. Relevant topics will include practical applications of criteria and approaches for the structural analysis, of requirements and design protocols for the structural design of marine structures, including instability verification, advanced fatigue methods, requirements against seismic actions and exceptional loadings. The topics will be mainly presented through case studies, exercises and direct application by the students. At the end of the course the students will be able to develop structural analysis and practical design of marine structures.            The course contributes to the objectives of the master's course related to structural design and natural risk management.</p>						
6708 000 000 B5608 - 0 - ANALYSIS AND MODELLING OF MARINE STRUCTURES	ICAR/08	CEAR-06/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b>            Obiettivi: The course focuses on the fundamental principles of structural dynamics and fatigue analysis applied to marine structures. Students will explore the behavior of offshore and coastal constructions under various environmental loads, utilizing finite element modeling techniques to analyze stress responses, durability, and performance over time. Key topics include load assessment, structural response modeling, and techniques for predicting and mitigating fatigue in marine environments. Through hands-on applications and simulations, students gain practical skills in applying advanced modeling tools to enhance the reliability and safety of marine infrastructures.            Obiettivi inglese: The course focuses on the fundamental principles of structural dynamics and fatigue analysis applied to marine structures. Students will explore the behavior of offshore and coastal constructions under various environmental loads, utilizing finite element modeling techniques to analyze stress responses, durability, and performance over time. Key topics include load assessment, structural response modeling, and techniques for predicting and mitigating fatigue in marine environments. Through hands-on applications and simulations, students gain practical skills in applying advanced modeling tools to enhance the reliability and safety of marine infrastructures.</p>						
6708 000 000 B5610 - 0 - DESIGN OF MARINE STRUCTURES	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b>            Obiettivi: The student will acquire knowledge related to the structural design of the main typologies of marine structures, with respect to conceptual, formal and operational aspects. Relevance will be done both at off-shore and harbor structures. At the end of the course the students will be able to evaluate the mechanical behavior of marine structures, to develop the fundamental stages of the design process and structural analysis, including a proper choice of the building materials. The course contributes to the objectives of the master's course related to structural design and natural risk management.            Obiettivi inglese: The student will acquire knowledge related to the structural design of the main typologies of marine structures, with respect to conceptual, formal and operational aspects. Relevance will be done both at off-shore and harbor structures. At the end of the course the students will be able to evaluate the mechanical behavior of marine structures, to develop the fundamental stages of the design process and structural analysis, including a proper choice of the building materials. The course contributes to the objectives of the master's course related to structural design and natural risk management.</p>						
6708 000 000 B5612 - 0 - ENVIRONMENTAL PERSPECTIVES FOR MULTIMODAL TRANSPORT OPERATIONS	ICAR/05	CEAR-03/B	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b>            Obiettivi: The course aims at studying intermodal systems for the transportation of goods and of their performance, which is the consequence of the interactions between the different components - both operational and infrastructural.            The course aims at training engineers capable of tackling and solving problems in complex systems, with multidisciplinary skills and approaches. Students will acquire a solid preparation in the field of transportation systems engineering for the planning of activities in freight transportation nodes and for the management of freight and commodity flows.            Topics to be covered are methods and models of design, planning, evaluation of the performance and impacts of operations relating to freight transportation, optimization of freight transportation operations according to criteria of environmental sustainability and economic efficiency, in a systemic approach.            The main objectives are: 1) Ability to design and plan transportation systems from a systemic perspective and with a modelling and multidisciplinary approach in a changing context. 2) Ability to identify advantages and limits of applicability of scenarios and design solutions, with particular reference to the availability of resources and the effects of the intervention. 3) Ability to address the issues of transport systems engineering on a professional level, as well as to understand the link between transport systems, energy sources, infrastructures and territory.            Obiettivi inglese: The course aims at studying intermodal systems for the transportation of goods and of their performance, which is the consequence of the interactions between the different components - both operational and infrastructural.            The course aims at training engineers capable of tackling and solving problems in complex systems, with multidisciplinary skills and approaches. Students will acquire a solid preparation in the field of transportation systems engineering for the planning of activities in freight transportation nodes and for the management of freight and commodity flows.            Topics to be covered are methods and models of design, planning, evaluation of the performance and impacts of operations relating to freight transportation, optimization of freight transportation operations according</p>						

to criteria of environmental sustainability and economic efficiency, in a systemic approach.

The main objectives are: 1) Ability to design and plan transportation systems from a systemic perspective and with a modelling and multidisciplinary approach in a changing context. 2) Ability to identify advantages and limits of applicability of scenarios and design solutions, with particular reference to the availability of resources and the effects of the intervention. 3) Ability to address the issues of transport systems engineering on a professional level, as well as to understand the link between transport systems, energy sources, infrastructures and territory.

6708 000 000 B6349 - 0 - FOUNDATIONS AND ANCHORS	ICAR/07	CEAR-05/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente			D			
Obiettivi: The course provides students with the ability to apply the concepts of soil mechanics and geotechnical engineering to the modelling and design of the foundations of bottom-fixed and floating offshore structures. Particular emphasis is given to the foundations and anchors that support and moor offshore wind turbines.						
Obiettivi inglese: The course provides students with the ability to apply the concepts of soil mechanics and geotechnical engineering to the modelling and design of the foundations of bottom-fixed and floating offshore structures. Particular emphasis is given to the foundations and anchors that support and moor offshore wind turbines.						
6708 000 000 B5611 - 0 - GEOTECHNICAL DESIGN OF COASTAL INFRASTRUCTURES	ICAR/07	CEAR-05/A	3	24/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile			B			
Obiettivi: Il corso presenta una prospettiva geomeccanica sui processi che caratterizzano le zone costiere e la loro evoluzione nonché sul progetto di infrastrutture costiere, sul loro monitoraggio e valutazione del rischio						
Obiettivi inglese: The course offers a geomechanical perspective on nearshore processes and shoreline evolution, coastal infrastructure design, monitoring and risk assessment, in the context of a changing climate. At the end of the course the students will be able to develop a suitable geotechnical model based on site characterisation and field measurements. The students will also tackle the analysis of geotechnical solutions that aim at mitigating the coastal erosion and providing protection against the sea level rise.						
6708 000 000 B6326 - 0 - MATERIALS DURABILITY	ING-IND/22	IMAT-01/A	9	72/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente			D			
Obiettivi: The aim of the course is to introduce the students to the use of metal alloys and concrete suitable for offshore installations and equipment. Knowledge on the corrosion mechanism and protection systems as well as concrete durability in harsh marine environment will be provided.						
Obiettivi inglese: The aim of the course is to introduce the students to the use of metal alloys and concrete suitable for offshore installations and equipment. Knowledge on the corrosion mechanism and protection systems as well as concrete durability in harsh marine environment will be provided.						
6708 000 000 78724 - 0 - OCEAN AND COASTAL ENGINEERING	ICAR/01	CEAR-01/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile			B			
Obiettivi: Al termine dell'insegnamento gli studenti saranno in grado di condurre una caratterizzazione di base dell'ambiente marino (livello del mare, onde, correnti e vento) e di stimare le condizioni climatiche, le azioni marine e le condizioni di progetto su strutture offshore e costiere.						
Obiettivi inglese: The student at the end of the course is able to perform basic characterization of the ocean environment (sea water level, sea waves, currents and wind) and to estimate the climate and design conditions and sea actions on the offshore and coastal structures.						
6708 000 000 B6332 - 0 - OFFSHORE SURVEYS	ICAR/06	CEAR-04/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente			D			
Obiettivi: Through this course the students acquire basic knowledge of surveying technologies offered by geomatics for offshore engineering. They learn the basic on geodetic reference frame, reference systems, mapping projections and the use of space-geodetic techniques, with a focus on GNSS suitable for positioning, monitoring and navigation in offshore environment. Some elements on pipeline positioning and underwater positioning will be provided.						
Obiettivi inglese: Through this course the students acquire basic knowledge of surveying technologies offered by geomatics for offshore engineering. They learn the basic on geodetic reference frame, reference systems, mapping projections and the use of space-geodetic techniques, with a focus on GNSS suitable for positioning, monitoring and navigation in offshore environment. Some elements on pipeline positioning and underwater positioning will be provided.						

6708 000 000 B6479 - 0 - SCIENCE OF CLIMATE CHANGE	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente						D
Obiettivi: Students will learn what knowledge is needed to identify solutions to climate change mitigation and adaptation. They will learn how climate change can be mitigated, how adaptation may be carried out and how mitigation and adaptation interact each other. Students will learn what we know and what we still do not know about climate and climate change. They will also know what contribution they can give to resolve the climate challenge in both their roles of citizens and experts. The involved disciplines are: climate dynamics, climate analysis and modelling, geo-environmental sciences and water cycle, climate engineering and environmental engineering. The approach will be interdisciplinary with the aim to move to transdisciplinarity, namely, by setting the basis for an innovative scientific and technical approach.						
Obiettivi inglese: Students will learn what knowledge is needed to identify solutions to climate change mitigation and adaptation. They will learn how climate change can be mitigated, how adaptation may be carried out and how mitigation and adaptation interact each other. Students will learn what we know and what we still do not know about climate and climate change. They will also know what contribution they can give to resolve the climate challenge in both their roles of citizens and experts. The involved disciplines are: climate dynamics, climate analysis and modelling, geo-environmental sciences and water cycle, climate engineering and environmental engineering. The approach will be interdisciplinary with the aim to move to transdisciplinarity, namely, by setting the basis for an innovative scientific and technical approach.						
6708 000 000 B6353 - 0 - WIND AND OCEAN ENERGY I.C			6			Voto
Modulo integrato: B6354 - DESIGN PROJECT OF ELECTRIC ENGINEERING FOR WIND AND OCEAN ENERGY			3	0/0/24/0	No	
<b>Ambito:</b> 1008 - A scelta dello studente						D
Obiettivi: At the end of the course the student will have developed a basic background on electric energy conversion systems for offshore renewable sources, typical architectures and design criteria of offshore renewable power plants, technologies for electric energy transmission to the shore.						
Obiettivi inglese: At the end of the course the student will have developed a basic background on electric energy conversion systems for offshore renewable sources, typical architectures and design criteria of offshore renewable power plants, technologies for electric energy transmission to the shore.						
Modulo integrato: B6355 - PRINCIPLES OF WIND AND OCEAN ENERGY CONVERSION	ICAR/01	CEAR-01/A	3	24/0/0/0	No	
<b>Ambito:</b> 1008 - A scelta dello studente						D
Obiettivi: The students of this course will learn the principles of energy conversion from the sea, specifically waves, tidal range (tidal rise and fall), tidal and ocean currents, ocean currents, ocean thermal energy conversion, salinity gradients and from offshore wind. They will be able to perform assessment on the energy production and concept design of wave energy converters.						
Obiettivi inglese: The students of this course will learn the principles of energy conversion from the sea, specifically waves, tidal range (tidal rise and fall), tidal and ocean currents, ocean currents, ocean thermal energy conversion, salinity gradients and from offshore wind. They will be able to perform assessment on the energy production and concept design of wave energy converters.						

**Anno Accademico** 2026/2027  
**Classe** LM-23 R-INGEGNERIA CIVILE  
**Corso** 6708-CIVIL ENGINEERING

## Curriculum: CURRICULUM STRUCTURAL ENGINEERING (A28)

### Primo Anno di Corso

#### Gruppo: 1) Mandatory courses

TAF: Ambito:

Cfu min: Cfu max:

Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6708 000 000 72756 - 0 - ADVANCED DESIGN OF STRUCTURES		ICAR/09	CEAR-07/A		9	72/0/0/0	No	Voto

Ambito: 206 - Ingegneria civile

Obiettivi: Students will gain in-depth knowledge of the structural behavior of reinforced concrete (Module 1), prestressed concrete, steel, and composite structures (Module 2). They will introduced to advanced concepts and methods for the verification, modeling, and design of these structures, covering topics such as: failure and serviceability limit states, the role of ductility at both sectional and structural levels, longterm effects (including concrete creep, shrinkage, and steel relaxation), the effects of precompression on RC elements, plates under transverse loads, cylindrical shells and tanks, bracing systems, built-up steel columns, buckling issues, and stud bolt connectors in composite beams.

By the end of the course, students will be able to develop preliminary design and verifications of steel and RC structures (frames and plates), both in terms of ultimate and serviceability limit states; they could also determine the amount of reinforcement and draw the most important structural details. They will be also equipped to independently tackle the preliminary design of cylindrical tanks and prestressed beams. Reference will be made to European standards.

Obiettivi inglese: Students will gain in-depth knowledge of the structural behavior of reinforced concrete (Module 1), prestressed concrete, steel, and composite structures (Module 2). They will introduced to advanced concepts and methods for the verification, modeling, and design of these structures, covering topics such as: failure and serviceability limit states, the role of ductility at both sectional and structural levels, longterm effects (including concrete creep, shrinkage, and steel relaxation), the effects of precompression on RC elements, plates under transverse loads, cylindrical shells and tanks, bracing systems, built-up steel columns, buckling issues, and stud bolt connectors in composite beams.

By the end of the course, students will be able to develop preliminary design and verifications of steel and RC structures (frames and plates), both in terms of ultimate and serviceability limit states; they could also determine the amount of reinforcement and draw the most important structural details. They will be also equipped to independently tackle the preliminary design of cylindrical tanks and prestressed beams. Reference will be made to European standards.

6708 000 000 72757 - 0 - ADVANCED HYDROSYSTEMS ENGINEERING	ICAR/02	CEAR-01/B	9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: 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.</p> <p>Obiettivi inglese: 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.</p>						
6708 000 000 72758 - 0 - ADVANCED STRUCTURAL MECHANICS	ICAR/08	CEAR-06/A	9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance students' understanding of structural behavior and enhance their ability to apply structural analysis methods to civil engineering structures. Students will acquire knowledge in the following areas: Structural Matrix Analysis, i.e., techniques for analyzing 2D truss and frame structures using the Direct Stiffness Method and FEM software. Buckling Analysis, i.e., methods for buckling and post-buckling analysis of discrete and continuous systems, with FEM applications. Plastic Analysis, i.e., concepts of plasticity, incremental and limit analysis for truss and beam systems, also using FEM tools. The main skills developed during this course include: Proficiency in matrix analysis and the Finite Element Method (FEM) for analyzing truss and frame structures. Ability to evaluate buckling and post-buckling behavior of rigid and continuous systems, using equilibrium and energy methods. Competence in conducting plastic analysis of structural systems, including an understanding of plastic hinges. Software Proficiency: hands-on experience with FEM-based software for solving structural, buckling, and elasto-plastic problems. Analytical and critical thinking: enhanced ability to approach complex structural issues with theoretical and computational tools. The course contributes to the objectives of the master's program related to the application of mathematical tools for interpreting, describing, and modeling structural problems.</p> <p>Obiettivi inglese: The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance students' understanding of structural behavior and enhance their ability to apply structural analysis methods to civil engineering structures. Students will acquire knowledge in the following areas: Structural Matrix Analysis, i.e., techniques for analyzing 2D truss and frame structures using the Direct Stiffness Method and FEM software. Buckling Analysis, i.e., methods for buckling and post-buckling analysis of discrete and continuous systems, with FEM applications. Plastic Analysis, i.e., concepts of plasticity, incremental and limit analysis for truss and beam systems, also using FEM tools. The main skills developed during this course include: Proficiency in matrix analysis and the Finite Element Method (FEM) for analyzing truss and frame structures. Ability to evaluate buckling and post-buckling behavior of rigid and continuous systems, using equilibrium and energy methods. Competence in conducting plastic analysis of structural systems, including an understanding of plastic hinges. Software Proficiency: hands-on experience with FEM-based software for solving structural, buckling, and elasto-plastic problems. Analytical and critical thinking: enhanced ability to approach complex structural issues with theoretical and computational tools. The course contributes to the objectives of the master's program related to the application of mathematical tools for interpreting, describing, and modeling structural problems.</p>						
6708 000 000 72765 - 0 - GEOTECHNICAL ENGINEERING	ICAR/07	CEAR-05/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: The course aims to provide students with in-depth knowledge and practical skills in advanced soil mechanics and geotechnical modeling, focusing on applications in civil engineering design. By the end of the course, students will have gained a comprehensive understanding of the fundamental and advanced principles of soil behavior under various loading conditions, which are essential for assessing soil-structure interaction. They will acquire knowledge of geotechnical characterization methods, applicable both in laboratory and in situ, aligning with the program's objective to prepare students for design, construction, and stability assessments in civil engineering. In terms of skills, students will be proficient in evaluating and comparing key physical and mechanical soil parameters through experimental testing, integrating techniques from soil mechanics for geotechnical assessments. They will also be capable of applying geotechnical models for the design and stability analysis of primary geotechnical structures, in line with the CdS's emphasis on operational and methodological expertise in civil structure and infrastructure projects. Furthermore, students will develop the competence to conduct analyses of foundation and retaining structure stability, including complex soil behaviors and ensuring reliable, safety-oriented designs.</p> <p>Obiettivi inglese: The course aims to provide students with in-depth knowledge and practical skills in advanced soil mechanics and geotechnical modeling, focusing on applications in civil engineering design. By the end of the course, students will have gained a comprehensive understanding of the fundamental and advanced principles of soil behavior under various loading conditions, which are essential for assessing soil-structure interaction. They will acquire knowledge of geotechnical characterization methods, applicable both in laboratory and in situ, aligning with the program's objective to prepare students for design, construction, and stability assessments in civil engineering. In terms of skills, students will be proficient in evaluating and comparing key physical and mechanical soil parameters through experimental testing, integrating techniques from soil mechanics for geotechnical assessments. They will also be capable of applying geotechnical models for the design and stability analysis of primary geotechnical structures, in line with the CdS's emphasis on operational and methodological expertise in civil structure and infrastructure projects. Furthermore, students will develop the competence to conduct analyses of foundation and retaining structure stability, including complex soil behaviors and ensuring reliable, safety-oriented designs.</p>						

6708 000 000 72764 - 0 - NUMERICAL METHODS

MAT/08

MATH-05/A

12

96/0/0/0

No

Voto

**Ambito:** 2019 - Attività formative affini o integrative

C

Obiettivi: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to recognize, analyze and solve numerically on the computer some classes of mathematical problems naturally arising from modelling of physical systems subject to simulation/design in civil engineering.

Students will acquire knowledge in the following areas: (1) fundamentals of numerical analysis, such as types of numerical errors, machine numbers, posedness and conditioning of mathematical problems, convergence, stability, accuracy and (spatial and temporal) efficiency of numerical methods; (2) numerical solution of systems of linear equations; (3) numerical solution of non-linear equations and systems of non-linear equations; (4) numerical interpolation and approximation (fitting) of data and functions; (5) numerical differentiation and integration (quadrature) of functions; (6) numerical solution of (linear) differential equations of elliptic, parabolic and hyperbolic type, with focus on the finite difference method and some mention of the finite element method.

The main skills developed during this course include: (1) proficiency in recognizing classes of mathematical problems, analyzing them from posedness and conditioning point of views and, hence, predicting the difficulty of their numerical solution; (2) ability to choose the numerical method suitable for the solution of some classes of mathematical problems in accordance with the desired accuracy-efficiency tradeoff; (3) software competence: hands-on experience with using Matlab software and its programming language to implement algorithms and, in particular, numerical methods; (4) analytical and critical thinking: enhanced ability both to figure out the numerical algorithms running at the core of widely used simulation /design softwares in civil engineering, and to interpret their outputs from the numerical perspective.

The course contributes to the objectives of the master's program by completing and complementing the theoretical mathematical preparation acquired by students during the bachelor's degree with the knowledge and ability to solve numerically (on the computer) classes of mathematical problems of interest to civil engineering.

Obiettivi inglese: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to recognize, analyze and solve numerically on the computer some classes of mathematical problems naturally arising from modelling of physical systems subject to simulation/design in civil engineering.

Students will acquire knowledge in the following areas: (1) fundamentals of numerical analysis, such as types of numerical errors, machine numbers, posedness and conditioning of mathematical problems, convergence, stability, accuracy and (spatial and temporal) efficiency of numerical methods; (2) numerical solution of systems of linear equations; (3) numerical solution of non-linear equations and systems of non-linear equations; (4) numerical interpolation and approximation (fitting) of data and functions; (5) numerical differentiation and integration (quadrature) of functions; (6) numerical solution of (linear) differential equations of elliptic, parabolic and hyperbolic type, with focus on the finite difference method and some mention of the finite element method.

The main skills developed during this course include: (1) proficiency in recognizing classes of mathematical problems, analyzing them from posedness and conditioning point of views and, hence, predicting the difficulty of their numerical solution; (2) ability to choose the numerical method suitable for the solution of some classes of mathematical problems in accordance with the desired accuracy-efficiency tradeoff; (3) software competence: hands-on experience with using Matlab software and its programming language to implement algorithms and, in particular, numerical methods; (4) analytical and critical thinking: enhanced ability both to figure out the numerical algorithms running at the core of widely used simulation /design softwares in civil engineering, and to interpret their outputs from the numerical perspective.

The course contributes to the objectives of the master's program by completing and complementing the theoretical mathematical preparation acquired by students during the bachelor's degree with the knowledge and ability to solve numerically (on the computer) classes of mathematical problems of interest to civil engineering.

6708 000 000 95714 - 0 - SUSTAINABLE TRANSPORT SYSTEM DESIGN

ICAR/05

CEAR-03/B

9

72/0/0/0

No

Voto

**Ambito:** 206 - Ingegneria civile

B

Obiettivi: The course of Sustainable Transport System Design is split into two modules: the Sustainable Transportation Engineering module covers the basic elements of transportation systems engineering with reference to sustainable transport modelling and planning, while the Urban road mobility design and maintenance module focuses on the design of infrastructure to improve the sustainability of transport systems. The objective of the "Sustainable Transportation Engineering" module is to provide students with knowledge on sustainable transport planning framework. The module delves into supply- and demand-oriented methods and policies aimed at improving the environmental efficiency of transport systems. Students will learn theoretical and practical skills to model and simulate users' behaviour and transport systems performances and impacts, also in the context of new transportation technologies.

Obiettivi inglese: The course of Sustainable Transport System Design is split into two modules: the Sustainable Transportation Engineering module covers the basic elements of transportation systems engineering with reference to sustainable transport modelling and planning, while the Urban road mobility design and maintenance module focuses on the design of infrastructure to improve the sustainability of transport systems. The

objective of the "Sustainable Transportation Engineering" module is to provide students with knowledge on sustainable transport planning framework. The module delves into supply- and demand-oriented methods and policies aimed at improving the environmental efficiency of transport systems. Students will learn theoretical and practical skills to model and simulate users' behaviour and transport systems performances and impacts, also in the context of new transportation technologies.

**Gruppo: 2) Elective courses****TAF: F Ambito: 1147 - Altre conoscenze utili per****Cfu min: 6 Cfu max: 6**

Note: Choose 6 credits among the following courses:

**Attività formativa****TIP****SSD****SSD 2024****TAF****CFU****ORE F/E/L/N****FREQ. VER.**

6708 000 000 B8640 - 0 - ROAD AND TRANSPORTATION ENGINEERING DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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**Ambito:** 0000 - Nessun Ambito

F

**Obiettivi:** Students attending the course will develop the design of a road infrastructure, acquiring knowledge about the specific design standards and procedures. In particular the course will focus on the construction of a roundabout instead of an intersection in a real urban context. The student will obtain the skills necessary to design a roundabout in terms of pavement design, geometry and road signs. Interaction and collaboration between students will be fostered through the group work on the project.

**Obiettivi inglese:** Students attending the course will develop the design of a road infrastructure, acquiring knowledge about the specific design standards and procedures. In particular the course will focus on the construction of a roundabout instead of an intersection in a real urban context. The student will obtain the skills necessary to design a roundabout in terms of pavement design, geometry and road signs. Interaction and collaboration between students will be fostered through the group work on the project.

6708 000 000 B8638 - 0 - STRUCTURAL ENGINEERING DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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**Ambito:** 0000 - Nessun Ambito

F

**Obiettivi:** Students attending the course will delve into the study of the topics concerning the design of civil structures, acquiring knowledge about the specific design standards and procedures. Basic theoretical concepts, covered in other courses, will be recalled with the objective of applying them for the development of a project, regarding the design of a reinforced concrete building under static loading conditions. Students will also learn the use of a finite element software for the structural analysis and will develop blueprints using a CAD software. Interaction and collaboration between students will be fostered through the group work on the project.

**Obiettivi inglese:** Students attending the course will delve into the study of the topics concerning the design of civil structures, acquiring knowledge about the specific design standards and procedures. Basic theoretical concepts, covered in other courses, will be recalled with the objective of applying them for the development of a project, regarding the design of a reinforced concrete building under static loading conditions. Students will also learn the use of a finite element software for the structural analysis and will develop blueprints using a CAD software. Interaction and collaboration between students will be fostered through the group work on the project.

6708 000 000 B8639 - 0 - WATER ENGINEERING AND CLIMATE CHANGE ADAPTATION DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
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PROJECTS

F

**Ambito:** Students attending the course will delve into water engineering design projects. Students will acquire knowledge on standards and procedures towards resilient design solutions under changing climatic and socioeconomic conditions. Students will learn the use of open source softwares to analyse the water cycle and related hydraulic problems. Interaction and collaboration between students will be fostered through group activities during classes.

**Obiettivi inglese:** Students attending the course will delve into water engineering design projects. Students will acquire knowledge on standards and procedures towards resilient design solutions under changing climatic and socioeconomic conditions. Students will learn the use of open source softwares to analyse the water cycle and related hydraulic problems. Interaction and collaboration between students will be fostered through group activities during classes.

## Secondo Anno di Corso

### Gruppo: 1) Mandatory courses

**TAF: Ambito:**

**Cfu min: Cfu max:**

Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 72767 - 0 - MANAGING ENGINEERING AND CONSTRUCTION PROCESSES

ING-IND/35

IEGE-01/A

6

48/0/0/0

No

Voto

**Ambito:** 2019 - Attività formative affini o integrative

C

Obiettivi: A successful learner of this course will know the principles, methods and tools needed to manage and design construction processes. In addition, he or she will master elements of planning, estimation, scheduling, bidding and contractual relations, project cash flow evaluation, critical path method, as well as cost and effectiveness control.

Development of knowledge and skills:

- Knowledge:

Students will gain a deep understanding of projects in contemporary organizations. They will learn how to initiate, plan and execute a project, following it through its various phases. In addition, students will explore key approaches and theories for successful project management.

- Skills:

Through real-world case studies, problems and exercises, students will develop the ability to apply theoretical knowledge to real-world scenarios. During the course, project managers and entrepreneurs will come to class to share their experiences and comment on the opportunities and threats of managing complex projects around the world.

- Consistency with program objectives:

This course is designed to complement the overall objectives of the master's program by focusing on management-related topics that engineers should know in order to successfully enter the job market and advance in their professional careers.

Obiettivi inglese: A successful learner of this course will know the principles, methods and tools needed to manage and design construction processes. In addition, he or she will master elements of planning, estimation, scheduling, bidding and contractual relations, project cash flow evaluation, critical path method, as well as cost and effectiveness control.

Development of knowledge and skills:

- Knowledge:

Students will gain a deep understanding of projects in contemporary organizations. They will learn how to initiate, plan and execute a project, following it through its various phases. In addition, students will explore key approaches and theories for successful project management.

- Skills:

Through real-world case studies, problems and exercises, students will develop the ability to apply theoretical knowledge to real-world scenarios. During the course, project managers and entrepreneurs will come to class to share their experiences and comment on the opportunities and threats of managing complex projects around the world.

- Consistency with program objectives:

This course is designed to complement the overall objectives of the master's program by focusing on management-related topics that engineers should know in order to successfully enter the job market and advance in their professional careers.

6708 000 000 B8637 - 0 - SEMINARI IN LINGUA ITALIANA SULL'INGEGNERIA CIVILE

3

0/0/24/0

No

Giudizio

**Ambito:** 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro

F

Obiettivi: Course provides an updated overview of technological innovations in Civil Engineering, promotes understanding of environmental and sustainability challenges, encourages multidisciplinary collaboration and contributes to developing practical and applied skills, offering students the opportunity to develop hands-on skills through case studies workshops that allow them to apply theoretical concepts to real-world and contemporary scenarios. Furthermore the course promotes skills relates to the proficient use of technical language in Italian.

Obiettivi inglese: Course provides an updated overview of technological innovations in Civil Engineering, promotes understanding of environmental and sustainability challenges, encourages multidisciplinary collaboration and contributes to developing practical and applied skills, offering students the opportunity to develop hands-on skills through case studies workshops that allow them to apply theoretical concepts to real-world and contemporary scenarios. Furthermore the course promotes skills relates to the proficient use of technical language in Italian.

**Gruppo: 2) Final examination****TAF: Ambito:****Cfu min: 15 Cfu max: 15**

Note: Students can choose only the "Final examination" (Group A) or the "Final examination" and one of the learning activities among "Internship for preparation for the final examination", "Internship abroad for preparation for the final examination" or "Preparation for the final examination abroad" (Group B).

**Attività formative****TIP****SSD****SSD 2024****TAF****CFU****ORE F/E/L/N****FREQ. VER.**

2.1) Group A		0-15			
6708 000 000 60750 - 0 - FINAL EXAMINATION		15	0/0/0/0	No	
Ambito:	1018 - Per la prova finale	E			
Obiettivi: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
2.2) Group B		0-15			
6708 000 000 86301 - 0 - FINAL EXAMINATION		3	0/0/0/0	No	
Ambito:	1018 - Per la prova finale	E			
Obiettivi: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
6708 000 000 84551 - 1 - INTERNSHIP ABROAD FOR PREPARATION OF THE FINAL EXAMINATION		12	0/0/300/0	No	Giudizio
Ambito:	1018 - Per la prova finale	E			
Obiettivi: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.					
Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.					
6708 000 000 86296 - 1 - INTERNSHIP FOR PREPARATION FOR THE FINAL EXAMINATION		12	0/0/300/0	No	Giudizio
Ambito:	1018 - Per la prova finale	E			
Obiettivi: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.					
Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.					
6708 000 000 84548 - 1 - PREPARATION FOR THE FINAL EXAMINATION ABROAD		12	0/0/300/0	No	Giudizio
Ambito:	1018 - Per la prova finale	E			
Obiettivi: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.					
Obiettivi inglese: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.					

**Gruppo: 3) Elective courses****TAF: B Ambito: 206 - Ingegneria civile****Cfu min: 24 Cfu max: 24**

Note: Choose 24 CFU among the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 72769 - 0 - COMPUTATIONAL MECHANICS	ICAR/08	CEAR-06/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b>            Obiettivi: The Computational Mechanics course aims to provide students with the knowledge of the finite element method for solid and structural mechanics problems. Through this course, students will gain the theoretical and practical skills necessary to develop and implement the finite element method for a wide range of structural engineering problems and critically analyse the results. There is a strong emphasis on the computer implementation of algorithms in programming assignments. The application to real engineering problems is stressed throughout the course.</p> <p>Obiettivi inglese: The Computational Mechanics course aims to provide students with the knowledge of the finite element method for solid and structural mechanics problems. Through this course, students will gain the theoretical and practical skills necessary to develop and implement the finite element method for a wide range of structural engineering problems and critically analyse the results. There is a strong emphasis on the computer implementation of algorithms in programming assignments. The application to real engineering problems is stressed throughout the course.</p>						
6708 000 000 92874 - 0 - DESIGN OF FOUNDATIONS AND RETAINING STRUCTURES	ICAR/07	CEAR-05/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b>            Obiettivi: The course aims to apply the knowledge of geotechnical engineering to the design of civil engineering structures. Upon successful completion, students will be able to: understand the possible soil-structure interaction mechanisms of shallow and deep foundations; assess the modes of failure of rigid and flexible retaining structures; identify the fundamental features of well-established and more advanced analysis methods; recognize the potential of numerical methods, including the finite element method (FEM). The primary skills students will develop include: proficiency in selecting suitable soil parameters and alternative strategies for the design of foundations and retaining structures; competence in using software tools for geotechnical engineering; ability to apply relevant design codes and standards to geotechnical design.</p> <p>Obiettivi inglese: The course aims to apply the knowledge of geotechnical engineering to the design of civil engineering structures. Upon successful completion, students will be able to: understand the possible soil-structure interaction mechanisms of shallow and deep foundations; assess the modes of failure of rigid and flexible retaining structures; identify the fundamental features of well-established and more advanced analysis methods; recognize the potential of numerical methods, including the finite element method (FEM). The primary skills students will develop include: proficiency in selecting suitable soil parameters and alternative strategies for the design of foundations and retaining structures; competence in using software tools for geotechnical engineering; ability to apply relevant design codes and standards to geotechnical design.</p>						
6708 000 000 72781 - 0 - EARTHQUAKE ENGINEERING	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b>            Obiettivi: The course covers a blend of theoretical knowledge and practical skills aimed at understanding and mitigating the effects of seismic actions on civil engineering structures. Students will acquire knowledge on the following areas: seismology fundamentals, i.e. understanding the causes and mechanics of earthquakes; Structural Dynamics: i.e. how structures respond to dynamic loads, including single degree of freedom systems and multi degree of freedom systems; Hazard Assessment, i.e. learning methods for assessing seismic hazard in a given region; Elastic and Inelastic Response spectra; Earthquake Actions and Design Codes, i.e. structural analysis methods and seismic design criteria according to Eurocode 8 and Italian code; Performance-Based Design, i.e. approaches that consider different performance requirements for structures for different seismic ground motion intensities. The main skills developed are: ability to analyze seismic data and apply theoretical concepts to real-world scenarios; proficiency in using software tools for seismic structural analysis; competence in creating designs that comply with seismic standards, with reference to reinforced concrete structures; ability to convey technical information effectively.            The course contributes to the objectives of the master's course related to structural design and natural risk management.</p> <p>Obiettivi inglese: The course covers a blend of theoretical knowledge and practical skills aimed at understanding and mitigating the effects of seismic actions on civil engineering structures. Students will acquire knowledge on the following areas: seismology fundamentals, i.e. understanding the causes and mechanics of earthquakes; Structural Dynamics: i.e. how structures respond to dynamic loads, including single degree of freedom systems and multi degree of freedom systems; Hazard Assessment, i.e. learning methods for assessing seismic hazard in a given region; Elastic and Inelastic Response spectra; Earthquake Actions and Design Codes, i.e. structural analysis methods and seismic design criteria according to Eurocode 8 and Italian code; Performance-Based Design, i.e. approaches that consider different performance requirements for structures for different seismic ground motion intensities. The main skills developed are: ability to analyze seismic data and apply theoretical concepts to real-world scenarios; proficiency in using software tools for seismic structural analysis; competence in creating designs that comply with seismic standards, with reference to reinforced concrete structures; ability to convey technical information effectively.            The course contributes to the objectives of the master's course related to structural design and natural risk management.</p>						

6708 000 000 72782 - 0 - MECHANICS OF HISTORICAL MASONRY STRUCTURES

ICAR/08

CEAR-06/A

6

48/0/0/0

No

Voto

**Ambito:**

B

Obiettivi: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to analyze historical masonry structures. Covering several historical periods, from the Roman Empire to modern times, the course places special emphasis on Gothic architecture, renowned for its integration of architectural and structural elements.

**Knowledge and Skills Development:**

- Knowledge: Students will gain a deep understanding of load-bearing mechanisms in masonry structures, including arches, vaults, domes, walls, and pillars. They will also learn about the common failures these structures face when subjected to horizontal (seismic) actions. In addition, students will explore key theories, including the principle of virtual works and the use of the rigid no tension model, simplifying the analysis of masonry materials.

- Skills: Through case studies, exercises, and the use of numerical tools (such as line of thrust calculations for arches), students will develop the ability to apply theoretical knowledge to real-world scenarios. They will also learn how to diagnose structural issues and propose effective interventions. Additionally, students will construct a comprehensive glossary of masonry terms and gain a detailed understanding of masonry typologies, which are critical for the Masonry Quality Index. The course also includes the possibility of visits to significant historical structures, such as churches, to further reinforce the practical understanding of masonry structures.

**Coherence with Program Objectives:**

This course is designed to complement the overall objectives of the Civil Engineering program by focusing on the structural analysis of historical buildings. It provides students with foundational skills that will be essential for advanced studies and professional work in structural engineering, conservation, and rehabilitation. The integration of theoretical knowledge and practical application ensures that students are prepared to handle complex structural problems in their future careers.

Obiettivi inglese: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to analyze historical masonry structures. Covering several historical periods, from the Roman Empire to modern times, the course places special emphasis on Gothic architecture, renowned for its integration of architectural and structural elements.

**Knowledge and Skills Development:**

- Knowledge: Students will gain a deep understanding of load-bearing mechanisms in masonry structures, including arches, vaults, domes, walls, and pillars. They will also learn about the common failures these structures face when subjected to horizontal (seismic) actions. In addition, students will explore key theories, including the principle of virtual works and the use of the rigid no tension model, simplifying the analysis of masonry materials.

- Skills: Through case studies, exercises, and the use of numerical tools (such as line of thrust calculations for arches), students will develop the ability to apply theoretical knowledge to real-world scenarios. They will also learn how to diagnose structural issues and propose effective interventions. Additionally, students will construct a comprehensive glossary of masonry terms and gain a detailed understanding of masonry typologies, which are critical for the Masonry Quality Index. The course also includes the possibility of visits to significant historical structures, such as churches, to further reinforce the practical understanding of masonry structures.

**Coherence with Program Objectives:**

This course is designed to complement the overall objectives of the Civil Engineering program by focusing on the structural analysis of historical buildings. It provides students with foundational skills that will be essential for advanced studies and professional work in structural engineering, conservation, and rehabilitation. The integration of theoretical knowledge and practical application ensures that students are prepared to handle complex structural problems in their future careers.

6708 000 000 B8644 - 0 - STRUCTURAL RELIABILITY

ICAR/09

CEAR-07/A

6

48/0/0/0

No

Voto

**Ambito:**

206 - Ingegneria civile

B

Obiettivi: The student will acquire knowledge related to all aspects of structural reliability and conceptual structural design. The course will provide concepts to estimate the failure probability of structures and the structural behavior of complex buildings.

At the end of the course the student will be able to:

- master the basic principles of mathematical theory of probability applied to engineering
- estimate the uncertainties related to loads and strengths of structures
- master the basic principles of conceptual design of complex structures to predict their structural behavior
- estimate the uncertainties in structural behavior and its modelling
- calculate the reliability of simple structural systems
- understand the nature and origin of the current structural design code formats.

The course contributes to the objectives of the master's course related to structural design and natural risk management.

Obiettivi inglese: The student will acquire knowledge related to all aspects of structural reliability and conceptual structural design. The course will provide concepts to estimate the failure probability of structures and the structural behavior of complex buildings.

At the end of the course the student will be able to:

- master the basic principles of mathematical theory of probability applied to engineering
- estimate the uncertainties related to loads and strengths of structures
- master the basic principles of conceptual design of complex structures to predict their structural behavior
- estimate the uncertainties in structural behavior and its modelling

- calculate the reliability of simple structural systems
  - understand the nature and origin of the current structural design code formats.
- The course contributes to the objectives of the master's course related to structural design and natural risk management.

6708 000 000 72789 - 0 - STRUCTURAL STRENGTHENING & REHABILITATION	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
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**Ambito:**

Obiettivi: The course Structural Strengthening and Rehabilitation aims to give students a real structural design ability in many different areas through many different techniques. The course focuses on all materials present in existing structures like masonry, concrete, steel and timber. It includes various information and annotations on non-destructive testing of materials and evaluation of damage levels in historic structures, presenting them in the framework of Mohr-Coulomb materials.

The strengthening and rehabilitation design is developed by using traditional and innovative techniques. Among them, the case of restoration

with fibre-reinforced polymers is discussed in detail, presenting both the theoretical basis and the design rules, with applications to many important examples.

The course discusses several relevant cases of structural damage in detail: soil settlement, earthquake, fire, corrosion, and shock. Some cases of problem solutions are discussed in detail, by comparing the different strengthening techniques.

The analysis is mainly worked out with hand calculation so that students can widen their design capacity by applying themselves to some homework proposed at the end of the course, without the need for complex structural analysis programs.

The course is expected to form students for real professional strengthening activities, giving them the ability to investigate the damage severity and select the most appropriate strengthening technique.

Obiettivi inglese: The course Structural Strengthening and Rehabilitation aims to give students a real structural design ability in many different areas through many different techniques. The course focuses on all materials present in existing structures like masonry, concrete, steel and timber. It includes various information and annotations on non-destructive testing of materials and evaluation of damage levels in historic structures, presenting them in the framework of Mohr-Coulomb materials.

The strengthening and rehabilitation design is developed by using traditional and innovative techniques. Among them, the case of restoration

with fibre-reinforced polymers is discussed in detail, presenting both the theoretical basis and the design rules, with applications to many important examples.

The course discusses several relevant cases of structural damage in detail: soil settlement, earthquake, fire, corrosion, and shock. Some cases of problem solutions are discussed in detail, by comparing the different strengthening techniques.

The analysis is mainly worked out with hand calculation so that students can widen their design capacity by applying themselves to some homework proposed at the end of the course, without the need for complex structural analysis programs.

The course is expected to form students for real professional strengthening activities, giving them the ability to investigate the damage severity and select the most appropriate strengthening technique.

**Gruppo: 4) Courses freely chosen by the student****TAF: D Ambito: 1008 - A scelta dello studente****Cfu min: 12 Cfu max: 12**

Note: Choose 12 credits. The course board suggests to attend to the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 72803 - 0 - BIOTECHNOLOGY FOR THE SUSTAINABLE RECLAMATION OF CONTAMINATED LANDS AND WATERS	ICAR/03	CEAR-02/A		6	48/0/0/0	No	Voto
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**Ambito:**

Obiettivi: 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.

Obiettivi inglese: 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.

6708 000 000 86582 - 0 - BUILDING INFORMATION MODELING	ICAR/17	CEAR-10/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						D
Obiettivi: Il corso mira a formare gli allievi sull'ampio e crescente panorama degli strumenti di modellazione BIM fornendo il lessico di questa nuova forma di rappresentazione ed i metodi che stanno alla base del workflow integrato ad essa riferibile. Il corso prende in esame gli step alla base della BIM Technology e le novità da essa introdotta rispetto all'approccio alla progettazione, al controllo ed alla gestione del processo costruttivo. Viene, inoltre, fornita una ampia panoramica sull'insieme degli applicativi BIM ad oggi presenti sul mercato in modo da fornire gli strumenti critici per la valutazione degli applicativi più idonei alle esigenze progettuali.						
Obiettivi inglese: The course aims at training students on the broad and expanding field of BIM applications by providing a general lexicon, the concepts and techniques of this wide set of tools for management, representation and construction. Starting from a short summary of consolidated modelling techniques (CAD, 3D geometric modelling tools), the course considers both the "pillars" of BIM Technology (datum, contents, views, management) and the innovations introduced in the construction process by this approach to design. The course also provides a comprehensive overview of the main BIM applications currently in use, in order to develop a critical approach to these techniques and evaluate the most suitable solution to design issues.						
6708 000 000 95709 - 0 - CLIMATE CHANGE ADAPTATION	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
Obiettivi: Students of this course will learn solutions to climate change adaptation and their technical design, by focusing on extreme weather events - in particular floods and droughts - low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as an effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design. The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent re-search developments and will make use of open access information.						
Obiettivi inglese: Students of this course will learn solutions to climate change adaptation and their technical design, by focusing on extreme weather events - in particular floods and droughts - low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as an effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design. The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent re-search developments and will make use of open access information.						
6708 000 000 72769 - 0 - COMPUTATIONAL MECHANICS	ICAR/08	CEAR-06/A	6	48/0/0/0	No	Voto
<b>Ambito:</b>						B
Obiettivi: The Computational Mechanics course aims to provide students with the knowledge of the finite element method for solid and structural mechanics problems. Through this course, students will gain the theoretical and practical skills necessary to develop and implement the finite element method for a wide range of structural engineering problems and critically analyse the results. There is a strong emphasis on the computer implementation of algorithms in programming assignments. The application to real engineering problems is stressed throughout the course.						
Obiettivi inglese: The Computational Mechanics course aims to provide students with the knowledge of the finite element method for solid and structural mechanics problems. Through this course, students will gain the theoretical and practical skills necessary to develop and implement the finite element method for a wide range of structural engineering problems and critically analyse the results. There is a strong emphasis on the computer implementation of algorithms in programming assignments. The application to real engineering problems is stressed throughout the course.						
6708 000 000 B5615 - 0 - COMPUTATIONAL WIND ENGINEERING	ICAR/08	CEAR-06/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente						D
Obiettivi: The course presents the methodologies to be used for the analysis of wind sensitive structures, with particular emphasis on the use of Computational Fluid Dynamics (CFD). The goal of the course is to provide the students with the fundamental concepts and operating tools to solve current Wind Engineering problems using CFD. Students will gain competences regarding the arrangement of the wind flow around immersed obstacles, the generation of aerodynamic forces for streamlined and bluff bodies, as well as aeroelastic interactions.						
Obiettivi inglese: The course presents the methodologies to be used for the analysis of wind sensitive structures, with particular emphasis on the use of Computational Fluid Dynamics (CFD). The goal of the course is to provide the students with the fundamental concepts and operating tools to solve current Wind Engineering problems using CFD. Students will gain competences regarding the arrangement of the wind flow around immersed obstacles, the generation of aerodynamic forces for streamlined and bluff bodies, as well as aeroelastic interactions.						

6708 000 000 92874 - 0 - DESIGN OF FOUNDATIONS AND RETAINING STRUCTURES	ICAR/07	CEAR-05/A	6	48/0/0/0	No	Voto
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**Ambito:**

B

Obiettivi: The course aims to apply the knowledge of geotechnical engineering to the design of civil engineering structures. Upon successful completion, students will be able to: understand the possible soil-structure interaction mechanisms of shallow and deep foundations; assess the modes of failure of rigid and flexible retaining structures; identify the fundamental features of well-established and more advanced analysis methods; recognize the potential of numerical methods, including the finite element method (FEM). The primary skills students will develop include: proficiency in selecting suitable soil parameters and alternative strategies for the design of foundations and retaining structures; competence in using software tools for geotechnical engineering; ability to apply relevant design codes and standards to geotechnical design.

Obiettivi inglese: The course aims to apply the knowledge of geotechnical engineering to the design of civil engineering structures. Upon successful completion, students will be able to: understand the possible soil-structure interaction mechanisms of shallow and deep foundations; assess the modes of failure of rigid and flexible retaining structures; identify the fundamental features of well-established and more advanced analysis methods; recognize the potential of numerical methods, including the finite element method (FEM). The primary skills students will develop include: proficiency in selecting suitable soil parameters and alternative strategies for the design of foundations and retaining structures; competence in using software tools for geotechnical engineering; ability to apply relevant design codes and standards to geotechnical design.

6708 000 000 75204 - 0 - DESIGN OF LARGE-SCALE STRUCTURES	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
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**Ambito:**

1008 - A scelta dello studente

D

Obiettivi: A successful learner from this course will be able to: understand the static and dynamic behavior of large-scale structures such as tall buildings, large convention centers and major sports stadiums; understand the complete design process from initial design concepts on through all the major design decisions to the completion of detailed design; model the loadings acting on large - scale structures, also when the latter may interact with the loading itself, such as in the case of wind in large buildings or bridges.

Obiettivi inglese: A successful learner from this course will be able to: understand the static and dynamic behavior of large-scale structures such as tall buildings, large convention centers and major sports stadiums; understand the complete design process from initial design concepts on through all the major design decisions to the completion of detailed design; model the loadings acting on large - scale structures, also when the latter may interact with the loading itself, such as in the case of wind in large buildings or bridges.

6708 000 000 72781 - 0 - EARTHQUAKE ENGINEERING	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
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**Ambito:**

B

Obiettivi: The course covers a blend of theoretical knowledge and practical skills aimed at understanding and mitigating the effects of seismic actions on civil engineering structures. Students will acquire knowledge on the following areas: seismology fundamentals, i.e. understanding the causes and mechanics of earthquakes; Structural Dynamics: i.e. how structures respond to dynamic loads, including single degree of freedom systems and multi degree of freedom systems; Hazard Assessment, i.e. learning methods for assessing seismic hazard in a given region; Elastic and Inelastic Response spectra; Earthquake Actions and Design Codes, i.e. structural analysis methods and seismic design criteria according to Eurocode 8 and Italian code; Performance-Based Design, i.e. approaches that consider different performance requirements for structures for different seismic ground motion intensities. The main skills developed are: ability to analyze seismic data and apply theoretical concepts to real-world scenarios; proficiency in using software tools for seismic structural analysis; competence in creating designs that comply with seismic standards, with reference to reinforced concrete structures; ability to convey technical information effectively.

The course contributes to the objectives of the master's course related to structural design and natural risk management.

Obiettivi inglese: The course covers a blend of theoretical knowledge and practical skills aimed at understanding and mitigating the effects of seismic actions on civil engineering structures. Students will acquire knowledge on the following areas: seismology fundamentals, i.e. understanding the causes and mechanics of earthquakes; Structural Dynamics: i.e. how structures respond to dynamic loads, including single degree of freedom systems and multi degree of freedom systems; Hazard Assessment, i.e. learning methods for assessing seismic hazard in a given region; Elastic and Inelastic Response spectra; Earthquake Actions and Design Codes, i.e. structural analysis methods and seismic design criteria according to Eurocode 8 and Italian code; Performance-Based Design, i.e. approaches that consider different performance requirements for structures for different seismic ground motion intensities. The main skills developed are: ability to analyze seismic data and apply theoretical concepts to real-world scenarios; proficiency in using software tools for seismic structural analysis; competence in creating designs that comply with seismic standards, with reference to reinforced concrete structures; ability to convey technical information effectively.

The course contributes to the objectives of the master's course related to structural design and natural risk management.

6708 000 000 72805 - 0 - ENGINEERING GEOLOGY	GEO/05	GEOS-03/B	6	48/0/0/0	No	Voto
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**Ambito:**

D

Obiettivi: Engineering Geology explores engineering and environmental challenges stemming from interactions between geology and human activities, aiming to build understanding of geological processes and their impact on engineering design.

Upon successful completion of this course, students will be able to:

Analyze Geological Processes: Demonstrate a comprehensive understanding of geological and geomorphological processes, assessing their implications for engineering and environmental projects.

Interpret Geological Data: Critically analyze and interpret geological data from various sources, including maps and site investigation reports, to make informed engineering geological decisions.

Assess Geological Hazards: Evaluate geological hazards, with a focus on mass movements, and develop geological models to inform engineering decisions.

Develop Preventive and Remedial Measures: Formulate strategies to prevent and mitigate the impacts of geological hazards, with a focus on mass movements, including recommendations for site-specific interventions.

Collaborate with Multidisciplinary Teams: Communicate effectively with professionals across disciplines, contributing geological insights to multidisciplinary engineering and environmental design.

Obiettivi inglese: Engineering Geology explores engineering and environmental challenges stemming from interactions between geology and human activities, aiming to build understanding of geological processes and their impact on engineering design.

Upon successful completion of this course, students will be able to:

Analyze Geological Processes: Demonstrate a comprehensive understanding of geological and geomorphological processes, assessing their implications for engineering and environmental projects.

Interpret Geological Data: Critically analyze and interpret geological data from various sources, including maps and site investigation reports, to make informed engineering geological decisions.

Assess Geological Hazards: Evaluate geological hazards, with a focus on mass movements, and develop geological models to inform engineering decisions.

Develop Preventive and Remedial Measures: Formulate strategies to prevent and mitigate the impacts of geological hazards, with a focus on mass movements, including recommendations for site-specific interventions.

Collaborate with Multidisciplinary Teams: Communicate effectively with professionals across disciplines, contributing geological insights to multidisciplinary engineering and environmental design.

6708 000 000 78594 - 0 - FLOOD AND DROUGHT RISK MANAGEMENT	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
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**Ambito:**

B

Obiettivi: The objective of this course is to provide students with the understanding of the factors causing floods and droughts and with the knowledge both of the methods for quantifying and of the options for reducing such water risks. By the end of the course, students have the knowledge of the data requirement and methods used for the assessment of river flood and drought risk, in terms of hazard, exposure and vulnerability.

Students will also learn about the measures available for mitigating and managing such risks (such as structures for flood defense, flood and drought policies/plans/mapping; forecasting and warning systems).

Applied skills: through the development of the assignments, students will apply their knowledge to obtain and process their own real-world meteo-hydrological data and to use them for i) computing meteorological and hydrological drought indicators and ii) estimating design floods.

Obiettivi inglese: The objective of this course is to provide students with the understanding of the factors causing floods and droughts and with the knowledge both of the methods for quantifying and of the options for reducing such water risks. By the end of the course, students have the knowledge of the data requirement and methods used for the assessment of river flood and drought risk, in terms of hazard, exposure and vulnerability.

Students will also learn about the measures available for mitigating and managing such risks (such as structures for flood defense, flood and drought policies/plans/mapping; forecasting and warning systems).

Applied skills: through the development of the assignments, students will apply their knowledge to obtain and process their own real-world meteo-hydrological data and to use them for i) computing meteorological and hydrological drought indicators and ii) estimating design floods.

6708 000 000 B5516 - 0 - GEOMATICS FOR GIS	ICAR/06	CEAR-04/A	6	48/0/0/0	No	Voto
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**Ambito:**

206 - Ingegneria civile

B

Obiettivi: Il corso approfondisce l'uso dei Sistemi Informativi Geografici (GIS) e le moderne tecnologie offerte dalla Geomatica per la raccolta, la gestione e l'analisi dei dati geospaziali. Gli studenti acquisiscono consapevolezza delle potenzialità e dei limiti delle tecniche di rappresentazione metrica del territorio o di specifiche infrastrutture, specialmente in termini di accuratezza e produttività, e apprendono come sceglierle ed integrarle per supportare diverse applicazioni dell'ingegneria ambientale e civile.

Obiettivi inglese: The course provides insights into the use of Geographical Information Systems (GIS) and the modern technologies offered by Geomatics to collect, manage and analyse geospatial data. Students gain awareness on potentials and limitations of the techniques for the metric representation of the landscape or of specific infrastructures, especially in terms of accuracy and productivity, and learn how to choose and integrate them to support different environmental and civil engineering applications.

6708 000 000 78593 - 0 - GROUNDWATER AND CONTAMINATION PROCESSES	ICAR/01	CEAR-01/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
<p>Obiettivi: The course provides fundamentals of subsurface flow and transport, emphasizing the primary role of groundwater in the hydrologic cycle, the relation of groundwater flow to hydrogeological properties, and the management of contaminated groundwater. Effective methods for the prediction and interpretation of groundwater processes will be discussed together with engineering implications. These include basics of infrastructure design related to the subsurface environment. Particular attention will be reserved to well hydraulics having several implications in water exploitation, monitoring and remediation. Description and analysis of both synthetic and real case studies will provide the opportunity to jointly apply concepts and methods discussed during the course.</p> <p>Obiettivi inglese: The course provides fundamentals of subsurface flow and transport, emphasizing the primary role of groundwater in the hydrologic cycle, the relation of groundwater flow to hydrogeological properties, and the management of contaminated groundwater. Effective methods for the prediction and interpretation of groundwater processes will be discussed together with engineering implications. These include basics of infrastructure design related to the subsurface environment. Particular attention will be reserved to well hydraulics having several implications in water exploitation, monitoring and remediation. Description and analysis of both synthetic and real case studies will provide the opportunity to jointly apply concepts and methods discussed during the course.</p>						
6708 000 000 95813 - 0 - LARGE-SCALE WATER STRUCTURES	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
<b>Ambito:</b>						B
<p>Obiettivi: Students will learn advanced theoretical concepts and operational tools for the design of large-scale water structures, including dams, reservoirs and hydro-power systems. Students will gain expertise on the hydraulic and management challenges of large-scale water structures and their environmental impact. Students will be able to check dam stability, design key hydraulic facilities and large-scale hydro-power plants. Case studies related to recently built water structures will be examined.</p> <p>Obiettivi inglese: Students will learn advanced theoretical concepts and operational tools for the design of large-scale water structures, including dams, reservoirs and hydro-power systems. Students will gain expertise on the hydraulic and management challenges of large-scale water structures and their environmental impact. Students will be able to check dam stability, design key hydraulic facilities and large-scale hydro-power plants. Case studies related to recently built water structures will be examined.</p>						
6708 000 000 72782 - 0 - MECHANICS OF HISTORICAL MASONRY STRUCTURES	ICAR/08	CEAR-06/A	6	48/0/0/0	No	Voto
<b>Ambito:</b>						B
<p>Obiettivi: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to analyze historical masonry structures. Covering several historical periods, from the Roman Empire to modern times, the course places special emphasis on Gothic architecture, renowned for its integration of architectural and structural elements.</p> <p>Knowledge and Skills Development:</p> <ul style="list-style-type: none"> <li>- Knowledge: Students will gain a deep understanding of load-bearing mechanisms in masonry structures, including arches, vaults, domes, walls, and pillars. They will also learn about the common failures these structures face when subjected to horizontal (seismic) actions. In addition, students will explore key theories, including the principle of virtual works and the use of the rigid no tension model, simplifying the analysis of masonry materials.</li> <li>- Skills: Through case studies, exercises, and the use of numerical tools (such as line of thrust calculations for arches), students will develop the ability to apply theoretical knowledge to real-world scenarios. They will also learn how to diagnose structural issues and propose effective interventions. Additionally, students will construct a comprehensive glossary of masonry terms and gain a detailed understanding of masonry typologies, which are critical for the Masonry Quality Index. The course also includes the possibility of visits to significant historical structures, such as churches, to further reinforce the practical understanding of masonry structures.</li> </ul> <p>Coherence with Program Objectives:</p> <p>This course is designed to complement the overall objectives of the Civil Engineering program by focusing on the structural analysis of historical buildings. It provides students with foundational skills that will be essential for advanced studies and professional work in structural engineering, conservation, and rehabilitation. The integration of theoretical knowledge and practical application ensures that students are prepared to handle complex structural problems in their future careers.</p> <p>Obiettivi inglese: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to analyze historical masonry structures. Covering several historical periods, from the Roman Empire to modern times, the course places special emphasis on Gothic architecture, renowned for its integration of architectural and structural elements.</p> <p>Knowledge and Skills Development:</p> <ul style="list-style-type: none"> <li>- Knowledge: Students will gain a deep understanding of load-bearing mechanisms in masonry structures, including arches, vaults, domes, walls, and pillars. They will also learn about the common failures these structures face when subjected to horizontal (seismic) actions. In addition, students will explore key theories, including the principle of virtual works and the use of the rigid no tension model, simplifying the analysis of masonry materials.</li> <li>- Skills: Through case studies, exercises, and the use of numerical tools (such as line of thrust calculations for arches), students will develop the ability to apply theoretical knowledge to real-world scenarios. They will also learn how to diagnose structural issues and propose effective interventions. Additionally, students will construct a comprehensive glossary of masonry terms and gain a detailed understanding of masonry typologies, which are critical for the Masonry Quality Index. The course also includes the possibility of visits to significant historical structures, such as churches, to further reinforce the practical understanding of masonry structures.</li> </ul> <p>Coherence with Program Objectives:</p> <p>This course is designed to complement the overall objectives of the Civil Engineering program by focusing on the structural analysis of historical buildings. It provides students with foundational skills that will be essential for advanced studies and professional work in structural engineering, conservation, and rehabilitation. The integration of theoretical knowledge and practical application ensures that students are prepared to handle complex structural problems in their future careers.</p>						

6708 000 000 78965 - 0 - PUBLIC PROCUREMENT	IUS/10	GIUR-06/A	6	48/0/0/0	No	Voto
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**Ambito:** 1008 - A scelta dello studente

D

**Obiettivi:** The aim of the course is to give a complete survey of the juridical and judicial landscape of the Italian and European systems in the topic of public procurement and contract.

**Obiettivi inglese:** The aim of the course is to give a complete survey of the juridical and judicial landscape of the Italian and European systems in the topic of public procurement and contract.

6708 000 000 78595 - 0 - ROAD SAFETY ENGINEERING	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
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**Ambito:** 1008 - A scelta dello studente

D

**Obiettivi:** The objectives of the unit are to gain a clear understanding of:

- why road safety is important, how we can achieve improvements and who is doing the work;
- the multidisciplinary nature of road safety and why we need to use a combination of engineering, education and enforcement to be successful;
- the behaviour of road users and ways in which the road environment can be designed/improved to cater for their needs;
- the complexity of the human/vehicle/road system and how the interrelationships work to influence the level of safety;
- what are the legal responsibilities of road authorities and decision makers and how they can fulfil them;
- how to undertake accident investigations;
- how to collect accident data and what to look for in quality data;
- how to analyse accident data, turn it into information and develop cost effective, practical counter measures;
- what needs to be done after treating a site and how to do it;
- how to be proactive in preventing accidents before they occur.

Specific skill sets developed in the class are:

- Analysis of traffic collision and injury data;
- Analysis of collision risk in a road network (network screening);
- Identifying crash causal factors;
- Identifying and evaluating countermeasures;
- Principles of Road Safety Management.
- What is the Road safety Audit procedure, and what are aims and objectives, roles and responsibility; history of road safety audit, road safety audit and design standards, road safety audit tasks, various stages of safety audits; common identifiable problems.
- How to structure a road safety audit report, identify common problems.
- Case studies and site visit; what to look for on site visits.

**Obiettivi inglese:** The objectives of the unit are to gain a clear understanding of:

- why road safety is important, how we can achieve improvements and who is doing the work;
- the multidisciplinary nature of road safety and why we need to use a combination of engineering, education and enforcement to be successful;
- the behaviour of road users and ways in which the road environment can be designed/improved to cater for their needs;
- the complexity of the human/vehicle/road system and how the interrelationships work to influence the level of safety;
- what are the legal responsibilities of road authorities and decision makers and how they can fulfil them;
- how to undertake accident investigations;
- how to collect accident data and what to look for in quality data;
- how to analyse accident data, turn it into information and develop cost effective, practical counter measures;
- what needs to be done after treating a site and how to do it;
- how to be proactive in preventing accidents before they occur.

Specific skill sets developed in the class are:

- Analysis of traffic collision and injury data;
- Analysis of collision risk in a road network (network screening);
- Identifying crash causal factors;
- Identifying and evaluating countermeasures;
- Principles of Road Safety Management.
- What is the Road safety Audit procedure, and what are aims and objectives, roles and responsibility; history of road safety audit, road safety audit and design standards, road safety audit tasks, various stages of safety audits; common identifiable problems.
- How to structure a road safety audit report, identify common problems.

- Case studies and site visit; what to look for on site visits.

6708 000 000 72807 - 0 - SCIENCE AND TECHNOLOGY OF COMPOSITE MATERIALS M	ING-IND/22	IMAT-01/A	6	48/0/0/0	No	Voto
D						
<p><b>Ambito:</b> 1008 - A scelta dello studente</p> <p>Obiettivi: Knowledge of properties, application and manufacturing technology of main composite materials. Comprehension of the mechanisms which allow to obtain particular properties on the basis of material components and their architecture. Ability in the choice of the most suitable composite material on the basis of the technological requirements of the product.</p> <p>Obiettivi inglese: Knowledge of properties, application and manufacturing technology of main composite materials. Comprehension of the mechanisms which allow to obtain particular properties on the basis of material components and their architecture. Ability in the choice of the most suitable composite material on the basis of the technological requirements of the product.</p>						
6708 000 000 B6479 - 0 - SCIENCE OF CLIMATE CHANGE	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
D						
<p><b>Ambito:</b> 1008 - A scelta dello studente</p> <p>Obiettivi: Students will learn what knowledge is needed to identify solutions to climate change mitigation and adaptation. They will learn how climate change can be mitigated, how adaptation may be carried out and how mitigation and adaptation interact each other. Students will learn what we know and what we still do not know about climate and climate change. They will also know what contribution they can give to resolve the climate challenge in both their roles of citizens and experts. The involved disciplines are: climate dynamics, climate analysis and modelling, geo-environmental sciences and water cycle, climate engineering and environmental engineering. The approach will be interdisciplinary with the aim to move to transdisciplinarity, namely, by setting the basis for an innovative scientific and technical approach.</p> <p>Obiettivi inglese: Students will learn what knowledge is needed to identify solutions to climate change mitigation and adaptation. They will learn how climate change can be mitigated, how adaptation may be carried out and how mitigation and adaptation interact each other. Students will learn what we know and what we still do not know about climate and climate change. They will also know what contribution they can give to resolve the climate challenge in both their roles of citizens and experts. The involved disciplines are: climate dynamics, climate analysis and modelling, geo-environmental sciences and water cycle, climate engineering and environmental engineering. The approach will be interdisciplinary with the aim to move to transdisciplinarity, namely, by setting the basis for an innovative scientific and technical approach.</p>						
6708 000 000 C8890 - 0 - STRUCTURAL ASSESSMENT AND MONITORING OF EXISTING STRUCTURES AND INFRASTRUCTURES	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
D						
<p><b>Ambito:</b> 1008 - A scelta dello studente</p> <p>Obiettivi: The course will cover the main concepts of structural life-cycle safety assessment for the management and maintenance of large and complex structures. Students will learn how to evaluate the safety of deteriorating structures; integrating analytical models, numerical simulations and experimental methods, with focus on risk mitigation and robustness</p> <p>Obiettivi inglese: The course will cover the main concepts of structural life-cycle safety assessment for the management and maintenance of large and complex structures. Students will learn how to evaluate the safety of deteriorating structures; integrating analytical models, numerical simulations and experimental methods, with focus on risk mitigation and robustness</p>						
6708 000 000 B8644 - 0 - STRUCTURAL RELIABILITY	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p>Obiettivi: The student will acquire knowledge related to all aspects of structural reliability and conceptual structural design. The course will provide concepts to estimate the failure probability of structures and the structural behavior of complex buildings.</p> <p>At the end of the course the student will be able to:</p> <ul style="list-style-type: none"> <li>- master the basic principles of mathematical theory of probability applied to engineering</li> <li>- estimate the uncertainties related to loads and strengths of structures</li> <li>- master the basic principles of conceptual design of complex structures to predict their structural behavior</li> <li>- estimate the uncertainties in structural behavior and its modelling</li> <li>- calculate the reliability of simple structural systems</li> <li>- understand the nature and origin of the current structural design code formats.</li> </ul> <p>The course contributes to the objectives of the master's course related to structural design and natural risk management.</p> <p>Obiettivi inglese: The student will acquire knowledge related to all aspects of structural reliability and conceptual structural design. The course will provide concepts to estimate the failure probability of structures and the structural behavior of complex buildings.</p> <p>At the end of the course the student will be able to:</p> <ul style="list-style-type: none"> <li>- master the basic principles of mathematical theory of probability applied to engineering</li> <li>- estimate the uncertainties related to loads and strengths of structures</li> <li>- master the basic principles of conceptual design of complex structures to predict their structural behavior</li> <li>- estimate the uncertainties in structural behavior and its modelling</li> </ul>						

- calculate the reliability of simple structural systems
  - understand the nature and origin of the current structural design code formats.
- The course contributes to the objectives of the master's course related to structural design and natural risk management.

6708 000 000 72789 - 0 - STRUCTURAL STRENGTHENING & REHABILITATION	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b></p> <p>Obiettivi: The course Structural Strengthening and Rehabilitation aims to give students a real structural design ability in many different areas through many different techniques. The course focuses on all materials present in existing structures like masonry, concrete, steel and timber. It includes various information and annotations on non-destructive testing of materials and evaluation of damage levels in historic structures, presenting them in the framework of Mohr-Coulomb materials.</p> <p>The strengthening and rehabilitation design is developed by using traditional and innovative techniques. Among them, the case of restoration with fibre-reinforced polymers is discussed in detail, presenting both the theoretical basis and the design rules, with applications to many important examples.</p> <p>The course discusses several relevant cases of structural damage in detail: soil settlement, earthquake, fire, corrosion, and shock. Some cases of problem solutions are discussed in detail, by comparing the different strengthening techniques.</p> <p>The analysis is mainly worked out with hand calculation so that students can widen their design capacity by applying themselves to some homework proposed at the end of the course, without the need for complex structural analysis programs.</p> <p>The course is expected to form students for real professional strengthening activities, giving them the ability to investigate the damage severity and select the most appropriate strengthening technique.</p> <p>Obiettivi inglese: The course Structural Strengthening and Rehabilitation aims to give students a real structural design ability in many different areas through many different techniques. The course focuses on all materials present in existing structures like masonry, concrete, steel and timber. It includes various information and annotations on non-destructive testing of materials and evaluation of damage levels in historic structures, presenting them in the framework of Mohr-Coulomb materials.</p> <p>The strengthening and rehabilitation design is developed by using traditional and innovative techniques. Among them, the case of restoration with fibre-reinforced polymers is discussed in detail, presenting both the theoretical basis and the design rules, with applications to many important examples.</p> <p>The course discusses several relevant cases of structural damage in detail: soil settlement, earthquake, fire, corrosion, and shock. Some cases of problem solutions are discussed in detail, by comparing the different strengthening techniques.</p> <p>The analysis is mainly worked out with hand calculation so that students can widen their design capacity by applying themselves to some homework proposed at the end of the course, without the need for complex structural analysis programs.</p> <p>The course is expected to form students for real professional strengthening activities, giving them the ability to investigate the damage severity and select the most appropriate strengthening technique.</p>						

6708 000 000 72748 - 0 - SUSTAINABILITY IN CONSTRUCTION	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p>Obiettivi: Course overview, introduction to sustainability. Definitions, trends, measurements. Aspects on sustainability (environmental, economic, social). Environmental footprint of engineered systems, with emphasis on civil engineering (energy consumptions, CO2 emissions, etc).</p> <p>Performance-based design and life-cycle planning. The various aspects to be considered for sustainability in construction: material's production and transformation, management of construction process, occupancy (use costs energy and cost consumptions), occupancy (maintenance and durability issues), end-of-life costs, reuse/recycling. Life-cycle analysis (LCA): Cradle-to-grave analysis, LCA as a min-max problem. Mathematical tools required (Optimization techniques, multi-criteria decision making methods, simulation methods, statistics). Social Life Cycle Assessment (S-LCA) and Ecologically based LCA (Eco-LCA). Safety as a prerequisite. Energy efficiency in buildings. Renewable energy with emphasis to building applications (solar thermal and photovoltaic energy, geothermal energy). Protocols for rating systems for the design, construction and operation of high performance green buildings (LEED system, Ithaca).</p> <p>Obiettivi inglese: Course overview, introduction to sustainability. Definitions, trends, measurements. Aspects on sustainability (environmental, economic, social). Environmental footprint of engineered systems, with emphasis on civil engineering (energy consumptions, CO2 emissions, etc).</p> <p>Performance-based design and life-cycle planning. The various aspects to be considered for sustainability in construction: material's production and transformation, management of construction process, occupancy (use costs energy and cost consumptions), occupancy (maintenance and durability issues), end-of-life costs, reuse/recycling. Life-cycle analysis (LCA): Cradle-to-grave analysis, LCA as a min-max problem. Mathematical tools required (Optimization techniques, multi-criteria decision making methods, simulation methods, statistics). Social Life Cycle Assessment (S-LCA) and Ecologically based LCA (Eco-LCA). Safety as a prerequisite. Energy efficiency in buildings. Renewable energy with emphasis to building applications (solar thermal and photovoltaic energy, geothermal energy). Protocols for rating systems for the design, construction and operation of high performance green buildings (LEED system, Ithaca).</p>						

6708 000 000 78737 - 0 - SUSTAINABLE BUILDING DESIGN	ICAR/10	CEAR-08/A	6	48/0/0/0	No	Voto
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**Ambito:** 1008 - A scelta dello studente

D

**Obiettivi:** The Training Objectives of the SUSTAINABLE BUILDING DESIGN course is to deliver knowledge for future construction managers and designers on the: i) optimization of site potential; optimization of energy use; optimize building spaces and material use. The course attenders will achieve design capabilities and skills within a total project context in order to achieve quality, high-energy performance up to nearly zero energy buildings (nZEBs).

**Obiettivi inglese:** The Training Objectives of the SUSTAINABLE BUILDING DESIGN course is to deliver knowledge for future construction managers and designers on the: i) optimization of site potential; optimization of energy use; optimize building spaces and material use. The course attenders will achieve design capabilities and skills within a total project context in order to achieve quality, high-energy performance up to nearly zero energy buildings (nZEBs).

6708 000 000 81509 - 0 - SUSTAINABLE ROAD INFRASTRUCTURES	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
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**Ambito:**

B

**Obiettivi:** Students will be introduced to road engineering and learn how these transportation infrastructures are conceived. A range of different externalities will be addressed and evaluated in order to identify the possible sustainable approaches towards the design and construction of less impacting roads. Emerging topics such as territory fragmentation and soil-bio engineering will be imparted as possible multidisciplinary solutions for the novel civil engineer that will know how to evaluate the impact of a road infrastructure on the territory and how to design the interventions to mitigate these effects, for a more sustainable infrastructure.

**Obiettivi inglese:** Students will be introduced to road engineering and learn how these transportation infrastructures are conceived. A range of different externalities will be addressed and evaluated in order to identify the possible sustainable approaches towards the design and construction of less impacting roads. Emerging topics such as territory fragmentation and soil-bio engineering will be imparted as possible multidisciplinary solutions for the novel civil engineer that will know how to evaluate the impact of a road infrastructure on the territory and how to design the interventions to mitigate these effects, for a more sustainable infrastructure.

**Anno Accademico** 2026/2027  
**Classe** LM-23 R-INGEGNERIA CIVILE  
**Corso** 6708-CIVIL ENGINEERING

## Curriculum: CURRICULUM SUSTAINABLE MOBILITY IN URBAN AREAS (I01)

### Primo Anno di Corso

#### Gruppo: 1) Mandatory courses

TAF: Ambito:

Cfu min: Cfu max:

Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
6708 000 000 72756 - 0 - ADVANCED DESIGN OF STRUCTURES		ICAR/09	CEAR-07/A		9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile				B				
<p>Obiettivi: Students will gain in-depth knowledge of the structural behavior of reinforced concrete (Module 1), prestressed concrete, steel, and composite structures (Module 2). They will introduced to advanced concepts and methods for the verification, modeling, and design of these structures, covering topics such as: failure and serviceability limit states, the role of ductility at both sectional and structural levels, longterm effects (including concrete creep, shrinkage, and steel relaxation), the effects of precompression on RC elements, plates under transverse loads, cylindrical shells and tanks, bracing systems, built-up steel columns, buckling issues, and stud bolt connectors in composite beams.</p> <p>By the end of the course, students will be able to develop preliminary design and verifications of steel and RC structures (frames and plates), both in terms of ultimate and serviceability limit states; they could also determine the amount of reinforcement and draw the most important structural details. They will be also equipped to independently tackle the preliminary design of cylindrical tanks and prestressed beams. Reference will be made to European standards.</p> <p>Obiettivi inglese: Students will gain in-depth knowledge of the structural behavior of reinforced concrete (Module 1), prestressed concrete, steel, and composite structures (Module 2). They will introduced to advanced concepts and methods for the verification, modeling, and design of these structures, covering topics such as: failure and serviceability limit states, the role of ductility at both sectional and structural levels, longterm effects (including concrete creep, shrinkage, and steel relaxation), the effects of precompression on RC elements, plates under transverse loads, cylindrical shells and tanks, bracing systems, built-up steel columns, buckling issues, and stud bolt connectors in composite beams.</p> <p>By the end of the course, students will be able to develop preliminary design and verifications of steel and RC structures (frames and plates), both in terms of ultimate and serviceability limit states; they could also determine the amount of reinforcement and draw the most important structural details. They will be also equipped to independently tackle the preliminary design of cylindrical tanks and prestressed beams. Reference will be made to European standards.</p>								

6708 000 000 72757 - 0 - ADVANCED HYDROSYSTEMS ENGINEERING	ICAR/02	CEAR-01/B	9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
Obiettivi: 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.						
Obiettivi inglese: 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.						
6708 000 000 72758 - 0 - ADVANCED STRUCTURAL MECHANICS	ICAR/08	CEAR-06/A	9	72/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
Obiettivi: The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance students' understanding of structural behavior and enhance their ability to apply structural analysis methods to civil engineering structures. Students will acquire knowledge in the following areas: Structural Matrix Analysis, i.e., techniques for analyzing 2D truss and frame structures using the Direct Stiffness Method and FEM software. Buckling Analysis, i.e., methods for buckling and post-buckling analysis of discrete and continuous systems, with FEM applications. Plastic Analysis, i.e., concepts of plasticity, incremental and limit analysis for truss and beam systems, also using FEM tools. The main skills developed during this course include: Proficiency in matrix analysis and the Finite Element Method (FEM) for analyzing truss and frame structures. Ability to evaluate buckling and post-buckling behavior of rigid and continuous systems, using equilibrium and energy methods. Competence in conducting plastic analysis of structural systems, including an understanding of plastic hinges. Software Proficiency: hands-on experience with FEM-based software for solving structural, buckling, and elasto-plastic problems. Analytical and critical thinking: enhanced ability to approach complex structural issues with theoretical and computational tools. The course contributes to the objectives of the master's program related to the application of mathematical tools for interpreting, describing, and modeling structural problems.						
Obiettivi inglese: The course is an extension and intensification of Mechanics of Solids and Structures. The goal of the course is to advance students' understanding of structural behavior and enhance their ability to apply structural analysis methods to civil engineering structures. Students will acquire knowledge in the following areas: Structural Matrix Analysis, i.e., techniques for analyzing 2D truss and frame structures using the Direct Stiffness Method and FEM software. Buckling Analysis, i.e., methods for buckling and post-buckling analysis of discrete and continuous systems, with FEM applications. Plastic Analysis, i.e., concepts of plasticity, incremental and limit analysis for truss and beam systems, also using FEM tools. The main skills developed during this course include: Proficiency in matrix analysis and the Finite Element Method (FEM) for analyzing truss and frame structures. Ability to evaluate buckling and post-buckling behavior of rigid and continuous systems, using equilibrium and energy methods. Competence in conducting plastic analysis of structural systems, including an understanding of plastic hinges. Software Proficiency: hands-on experience with FEM-based software for solving structural, buckling, and elasto-plastic problems. Analytical and critical thinking: enhanced ability to approach complex structural issues with theoretical and computational tools. The course contributes to the objectives of the master's program related to the application of mathematical tools for interpreting, describing, and modeling structural problems.						
6708 000 000 72765 - 0 - GEOTECHNICAL ENGINEERING	ICAR/07	CEAR-05/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile						B
Obiettivi: The course aims to provide students with in-depth knowledge and practical skills in advanced soil mechanics and geotechnical modeling, focusing on applications in civil engineering design. By the end of the course, students will have gained a comprehensive understanding of the fundamental and advanced principles of soil behavior under various loading conditions, which are essential for assessing soil-structure interaction. They will acquire knowledge of geotechnical characterization methods, applicable both in laboratory and in situ, aligning with the program's objective to prepare students for design, construction, and stability assessments in civil engineering. In terms of skills, students will be proficient in evaluating and comparing key physical and mechanical soil parameters through experimental testing, integrating techniques from soil mechanics for geotechnical assessments. They will also be capable of applying geotechnical models for the design and stability analysis of primary geotechnical structures, in line with the CdS's emphasis on operational and methodological expertise in civil structure and infrastructure projects. Furthermore, students will develop the competence to conduct analyses of foundation and retaining structure stability, including complex soil behaviors and ensuring reliable, safety-oriented designs.						
Obiettivi inglese: The course aims to provide students with in-depth knowledge and practical skills in advanced soil mechanics and geotechnical modeling, focusing on applications in civil engineering design. By the end of the course, students will have gained a comprehensive understanding of the fundamental and advanced principles of soil behavior under various loading conditions, which are essential for assessing soil-structure interaction. They will acquire knowledge of geotechnical characterization methods, applicable both in laboratory and in situ, aligning with the program's objective to prepare students for design, construction, and stability assessments in civil engineering. In terms of skills, students will be proficient in evaluating and comparing key physical and mechanical soil parameters through experimental testing, integrating techniques from soil mechanics for geotechnical assessments. They will also be capable of applying geotechnical models for the design and stability analysis of primary geotechnical structures, in line with the CdS's emphasis on operational and methodological expertise in civil structure and infrastructure projects. Furthermore, students will develop the competence to conduct analyses of foundation and retaining structure stability, including complex soil behaviors and ensuring reliable, safety-oriented designs.						

6708 000 000 72764 - 0 - NUMERICAL METHODS

MAT/08

MATH-05/A

12

96/0/0/0

No

Voto

**Ambito:** 2019 - Attività formative affini o integrative

C

Obiettivi: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to recognize, analyze and solve numerically on the computer some classes of mathematical problems naturally arising from modelling of physical systems subject to simulation/design in civil engineering.

Students will acquire knowledge in the following areas: (1) fundamentals of numerical analysis, such as types of numerical errors, machine numbers, posedness and conditioning of mathematical problems, convergence, stability, accuracy and (spatial and temporal) efficiency of numerical methods; (2) numerical solution of systems of linear equations; (3) numerical solution of non-linear equations and systems of non-linear equations; (4) numerical interpolation and approximation (fitting) of data and functions; (5) numerical differentiation and integration (quadrature) of functions; (6) numerical solution of (linear) differential equations of elliptic, parabolic and hyperbolic type, with focus on the finite difference method and some mention of the finite element method.

The main skills developed during this course include: (1) proficiency in recognizing classes of mathematical problems, analyzing them from posedness and conditioning point of views and, hence, predicting the difficulty of their numerical solution; (2) ability to choose the numerical method suitable for the solution of some classes of mathematical problems in accordance with the desired accuracy-efficiency tradeoff; (3) software competence: hands-on experience with using Matlab software and its programming language to implement algorithms and, in particular, numerical methods; (4) analytical and critical thinking: enhanced ability both to figure out the numerical algorithms running at the core of widely used simulation /design softwares in civil engineering, and to interpret their outputs from the numerical perspective.

The course contributes to the objectives of the master's program by completing and complementing the theoretical mathematical preparation acquired by students during the bachelor's degree with the knowledge and ability to solve numerically (on the computer) classes of mathematical problems of interest to civil engineering.

Obiettivi inglese: The aim of this course is to provide students with both the theoretical knowledge and practical skills required to recognize, analyze and solve numerically on the computer some classes of mathematical problems naturally arising from modelling of physical systems subject to simulation/design in civil engineering.

Students will acquire knowledge in the following areas: (1) fundamentals of numerical analysis, such as types of numerical errors, machine numbers, posedness and conditioning of mathematical problems, convergence, stability, accuracy and (spatial and temporal) efficiency of numerical methods; (2) numerical solution of systems of linear equations; (3) numerical solution of non-linear equations and systems of non-linear equations; (4) numerical interpolation and approximation (fitting) of data and functions; (5) numerical differentiation and integration (quadrature) of functions; (6) numerical solution of (linear) differential equations of elliptic, parabolic and hyperbolic type, with focus on the finite difference method and some mention of the finite element method.

The main skills developed during this course include: (1) proficiency in recognizing classes of mathematical problems, analyzing them from posedness and conditioning point of views and, hence, predicting the difficulty of their numerical solution; (2) ability to choose the numerical method suitable for the solution of some classes of mathematical problems in accordance with the desired accuracy-efficiency tradeoff; (3) software competence: hands-on experience with using Matlab software and its programming language to implement algorithms and, in particular, numerical methods; (4) analytical and critical thinking: enhanced ability both to figure out the numerical algorithms running at the core of widely used simulation /design softwares in civil engineering, and to interpret their outputs from the numerical perspective.

The course contributes to the objectives of the master's program by completing and complementing the theoretical mathematical preparation acquired by students during the bachelor's degree with the knowledge and ability to solve numerically (on the computer) classes of mathematical problems of interest to civil engineering.

6708 000 000 95714 - 0 - SUSTAINABLE TRANSPORT SYSTEM DESIGN

ICAR/05

CEAR-03/B

9

72/0/0/0

No

Voto

**Ambito:** 206 - Ingegneria civile

B

Obiettivi: The course of Sustainable Transport System Design is split into two modules: the Sustainable Transportation Engineering module covers the basic elements of transportation systems engineering with reference to sustainable transport modelling and planning, while the Urban road mobility design and maintenance module focuses on the design of infrastructure to improve the sustainability of transport systems. The objective of the "Sustainable Transportation Engineering" module is to provide students with knowledge on sustainable transport planning framework. The module delves into supply- and demand-oriented methods and policies aimed at improving the environmental efficiency of transport systems. Students will learn theoretical and practical skills to model and simulate users' behaviour and transport systems performances and impacts, also in the context of new transportation technologies.

Obiettivi inglese: The course of Sustainable Transport System Design is split into two modules: the Sustainable Transportation Engineering module covers the basic elements of transportation systems engineering with reference to sustainable transport modelling and planning, while the Urban road mobility design and maintenance module focuses on the design of infrastructure to improve the sustainability of transport systems. The

objective of the "Sustainable Transportation Engineering" module is to provide students with knowledge on sustainable transport planning framework. The module delves into supply- and demand-oriented methods and policies aimed at improving the environmental efficiency of transport systems. Students will learn theoretical and practical skills to model and simulate users' behaviour and transport systems performances and impacts, also in the context of new transportation technologies.

**Gruppo: 2) Elective courses****TAF: F Ambito: 1147 - Altre conoscenze utili per****Cfu min: 6 Cfu max: 6**

Note: Choose 6 credits among the following courses:

**Attività formativa****TIP****SSD****SSD 2024****TAF****CFU****ORE F/E/L/N****FREQ. VER.**

6708 000 000 B8640 - 0 - ROAD AND TRANSPORTATION ENGINEERING DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
<p><b>Ambito:</b> 0000 - Nessun Ambito</p> <p><b>Obiettivi:</b> Students attending the course will develop the design of a road infrastructure, acquiring knowledge about the specific design standards and procedures. In particular the course will focus on the construction of a roundabout instead of an intersection in a real urban context. The student will obtain the skills necessary to design a roundabout in terms of pavement design, geometry and road signs. Interaction and collaboration between students will be fostered through the group work on the project.</p> <p><b>Obiettivi inglese:</b> Students attending the course will develop the design of a road infrastructure, acquiring knowledge about the specific design standards and procedures. In particular the course will focus on the construction of a roundabout instead of an intersection in a real urban context. The student will obtain the skills necessary to design a roundabout in terms of pavement design, geometry and road signs. Interaction and collaboration between students will be fostered through the group work on the project.</p>	F			
6708 000 000 B8638 - 0 - STRUCTURAL ENGINEERING DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
<p><b>Ambito:</b> 0000 - Nessun Ambito</p> <p><b>Obiettivi:</b> Students attending the course will delve into the study of the topics concerning the design of civil structures, acquiring knowledge about the specific design standards and procedures. Basic theoretical concepts, covered in other courses, will be recalled with the objective of applying them for the development of a project, regarding the design of a reinforced concrete building under static loading conditions. Students will also learn the use of a finite element software for the structural analysis and will develop blueprints using a CAD software. Interaction and collaboration between students will be fostered through the group work on the project.</p> <p><b>Obiettivi inglese:</b> Students attending the course will delve into the study of the topics concerning the design of civil structures, acquiring knowledge about the specific design standards and procedures. Basic theoretical concepts, covered in other courses, will be recalled with the objective of applying them for the development of a project, regarding the design of a reinforced concrete building under static loading conditions. Students will also learn the use of a finite element software for the structural analysis and will develop blueprints using a CAD software. Interaction and collaboration between students will be fostered through the group work on the project.</p>	F			
6708 000 000 B8639 - 0 - WATER ENGINEERING AND CLIMATE CHANGE ADAPTATION DESIGN PROJECTS	3	0/0/24/0	No	Giudizio
<p><b>Ambito:</b></p> <p><b>Obiettivi:</b> Students attending the course will delve into water engineering design projects. Students will acquire knowledge on standards and procedures towards resilient design solutions under changing climatic and socioeconomic conditions. Students will learn the use of open source softwares to analyse the water cycle and related hydraulic problems. Interaction and collaboration between students will be fostered through group activities during classes.</p> <p><b>Obiettivi inglese:</b> Students attending the course will delve into water engineering design projects. Students will acquire knowledge on standards and procedures towards resilient design solutions under changing climatic and socioeconomic conditions. Students will learn the use of open source softwares to analyse the water cycle and related hydraulic problems. Interaction and collaboration between students will be fostered through group activities during classes.</p>	F			

## Secondo Anno di Corso

### Gruppo: 1) Mandatory courses

TAF: **Ambito:**

Cfu min: Cfu max:

Note:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 72767 - 0 - MANAGING ENGINEERING AND CONSTRUCTION PROCESSES

ING-IND/35

IEGE-01/A

6

48/0/0/0

No

Voto

**Ambito:** 2019 - Attività formative affini o integrative

C

Obiettivi: A successful learner of this course will know the principles, methods and tools needed to manage and design construction processes. In addition, he or she will master elements of planning, estimation, scheduling, bidding and contractual relations, project cash flow evaluation, critical path method, as well as cost and effectiveness control.

Development of knowledge and skills:

- Knowledge:

Students will gain a deep understanding of projects in contemporary organizations. They will learn how to initiate, plan and execute a project, following it through its various phases. In addition, students will explore key approaches and theories for successful project management.

- Skills:

Through real-world case studies, problems and exercises, students will develop the ability to apply theoretical knowledge to real-world scenarios. During the course, project managers and entrepreneurs will come to class to share their experiences and comment on the opportunities and threats of managing complex projects around the world.

- Consistency with program objectives:

This course is designed to complement the overall objectives of the master's program by focusing on management-related topics that engineers should know in order to successfully enter the job market and advance in their professional careers.

Obiettivi inglese: A successful learner of this course will know the principles, methods and tools needed to manage and design construction processes. In addition, he or she will master elements of planning, estimation, scheduling, bidding and contractual relations, project cash flow evaluation, critical path method, as well as cost and effectiveness control.

Development of knowledge and skills:

- Knowledge:

Students will gain a deep understanding of projects in contemporary organizations. They will learn how to initiate, plan and execute a project, following it through its various phases. In addition, students will explore key approaches and theories for successful project management.

- Skills:

Through real-world case studies, problems and exercises, students will develop the ability to apply theoretical knowledge to real-world scenarios. During the course, project managers and entrepreneurs will come to class to share their experiences and comment on the opportunities and threats of managing complex projects around the world.

- Consistency with program objectives:

This course is designed to complement the overall objectives of the master's program by focusing on management-related topics that engineers should know in order to successfully enter the job market and advance in their professional careers.

6708 000 000 B8637 - 0 - SEMINARI IN LINGUA ITALIANA SULL'INGEGNERIA CIVILE

3

0/0/24/0

No

Giudizio

**Ambito:** 1147 - Altre conoscenze utili per l'inserimento nel mondo del lavoro

F

Obiettivi: Course provides an updated overview of technological innovations in Civil Engineering, promotes understanding of environmental and sustainability challenges, encourages multidisciplinary collaboration and contributes to developing practical and applied skills, offering students the opportunity to develop hands-on skills through case studies workshops that allow them to apply theoretical concepts to real-world and contemporary scenarios. Furthermore the course promotes skills relates to the proficient use of technical language in Italian.

Obiettivi inglese: Course provides an updated overview of technological innovations in Civil Engineering, promotes understanding of environmental and sustainability challenges, encourages multidisciplinary collaboration and contributes to developing practical and applied skills, offering students the opportunity to develop hands-on skills through case studies workshops that allow them to apply theoretical concepts to real-world and contemporary scenarios. Furthermore the course promotes skills relates to the proficient use of technical language in Italian.

**Gruppo: 2) Final examination****TAF: Ambito:****Cfu min: 15 Cfu max: 15**

Note: Students can choose only the "Final examination" (Group A) or the "Final examination" and one of the learning activities among "Internship for preparation for the final examination", "Internship abroad for preparation for the final examination" or "Preparation for the final examination abroad" (Group B).

**Attività formative****TIP****SSD****SSD 2024****TAF****CFU****ORE F/E/L/N****FREQ. VER.**

2.1) Group A		0-15			
6708 000 000 60750 - 0 - FINAL EXAMINATION		15	0/0/0/0	No	
<b>Ambito:</b>	1018 - Per la prova finale	E			
<b>Obiettivi:</b> Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
2.2) Group B		0-15			
6708 000 000 86301 - 0 - FINAL EXAMINATION		3	0/0/0/0	No	
<b>Ambito:</b>	1018 - Per la prova finale	E			
<b>Obiettivi:</b> Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
Obiettivi inglese: Preparation for the final examination according to the provisions of the Teaching Regulation of the Program.					
6708 000 000 84551 - 1 - INTERNSHIP ABROAD FOR PREPARATION OF THE FINAL EXAMINATION		12	0/0/300/0	No	Giudizio
<b>Ambito:</b>	1018 - Per la prova finale	E			
<b>Obiettivi:</b> Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.					
Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation abroad, based on a internship project agreed with the supervisor.					
6708 000 000 86296 - 1 - INTERNSHIP FOR PREPARATION FOR THE FINAL EXAMINATION		12	0/0/300/0	No	Giudizio
<b>Ambito:</b>	1018 - Per la prova finale	E			
<b>Obiettivi:</b> Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.					
Obiettivi inglese: Promoting students' knowledge of the work field through thesis preparation, based on a internship project agreed with the supervisor.					
6708 000 000 84548 - 1 - PREPARATION FOR THE FINAL EXAMINATION ABROAD		12	0/0/300/0	No	Giudizio
<b>Ambito:</b>	1018 - Per la prova finale	E			
<b>Obiettivi:</b> With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.					
Obiettivi inglese: With the preparation for the final examination abroad, the students get a direct knowledge of the possible professional developments linked to the specific work and research field in line with master's programme.					

**Gruppo: 3) Elective courses****TAF: B Ambito: 206 - Ingegneria civile****Cfu min: 24 Cfu max: 24**

Note: Choose 24 CFU among the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ.	VER.
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6708 000 000 92872 - 0 - CIRCULAR-GREEN MANAGEMENT OF URBAN DRAINAGE	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile			B			
Obiettivi: Al termine del corso lo studente possiede conoscenze sulle soluzioni tecniche e sulla loro progettazione nel contesto della gestione circolare delle risorse idriche. In particolare, lo studente approfondirà:						
1. Il concetto di gestione circolare delle risorse idriche;						
2. Il clima nel 21 ° secolo: analisi degli impatti dei cambiamenti climatici sulle risorse idriche;						
3. Progettazione degli eventi climatici estremi nelle aree urbane soggette a cambiamenti climatici;						
4. Teoria delle decisioni per la gestione circolare delle risorse idriche;						
5. Best management practices (BMP) per la gestione del drenaggio delle acque;						
6. Analisi costi-benefici per le BMP;						
7. Qualità delle acque superficiali e sotterranee;						
8. L'obiettivo del riciclo dell'acqua al 100% e le relative implicazioni sulle emissioni di CO2.						
Obiettivi inglese: At the end of the course, the student will have knowledge on technical solutions and their design in the context of circular water resources management. In particular, the student will focus on:						
1. The concept of circular water resources management;						
2. Climate in the 21st century: review of climate change impacts on water resources;						
3. Estimation of design storm in urban areas under climate change and non-stationarity;						
4. Decision theory for circular water resources management;						
5. Best management practices (BMP) for drainage management;						
6. Cost-benefit analysis for BMPs;						
7. Surface and groundwater quality;						
8. The target of 100% water recycling and implications on CO2 emissions.						
6708 000 000 B5614 - 0 - DESIGN, MONITORING AND MANAGEMENT OF AIRPORTS	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile			B			
Obiettivi: Once completed the course, the student owns the required knowledge to design an air-port infrastructure, from both a geometric and structural standpoint. She/he knows the main elements that make up the two macro areas of the airport, Airside and Land side. In particular, for the Air side, he/she is able to design the pavement, the geometry, the signaling system, and all services for airport infrastructure. For the Land side and airport Terminal systems, he/she is capable of analyzing the connection between the different means of transport in the urban context with particular reference to the accessibility of nodes.						
Obiettivi inglese: Once completed the course, the student owns the required knowledge to design an air-port infrastructure, from both a geometric and structural standpoint. She/he knows the main elements that make up the two macro areas of the airport, Airside and Land side. In particular, for the Air side, he/she is able to design the pavement, the geometry, the signaling system, and all services for airport infrastructure. For the Land side and airport Terminal systems, he/she is capable of analyzing the connection between the different means of transport in the urban context with particular reference to the accessibility of nodes.						
6708 000 000 92869 - 0 - ROAD INFRASTRUCTURE SUSTAINABLE AND SAFE MANAGEMENT	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente			B			
Obiettivi: Lo studente del Corso di Road Infrastructure Sustainable and Safe Management affronterà i temi delle infrastrutture di trasporto in ambito urbano e metropolitano. Attraverso l'evoluzione delle infrastrutture stradali si giungerà al progetto della strada odierno con particolare riferimento alle sicurezza delle utenze deboli. Saranno illustrati gli aspetti legati al progetto della pavimentazione stradale in ambito urbano ed alla sua manutenzione. Tra le moderne soluzioni cittadine si proporranno i temi del riciclaggio dei materiali, della gestione dell'infrastruttura e delle linee di Trasporto Pubblico Locale.						
Obiettivi inglese: The student of the Road Infrastructure Sustainable and Safe Management Course will address the issues of transport infrastructure in urban and metropolitan areas. Through the evolution of the road infrastructures we will reach the project of today's road with particular reference to the safety of Vulnerable road users. The aspects related to the urban road pavement project and its maintenance will be illustrated. Among the modern city solutions the course will handle with the themes of material recycling, infrastructure management and Public Transport Infrastructure.						
6708 000 000 92867 - 0 - SURVEY AND MONITORING OF TRANSPORT INFRASTRUCTURES	ICAR/06	CEAR-04/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile			B			
Obiettivi: Al termine del corso, con il conseguimento dei crediti formativi, lo studente possiede le competenze necessarie al rilievo e monitoraggio delle infrastrutture di trasporto, dal progetto al supporto per la loro gestione, mediante tecniche geomatiche avanzate.						
Obiettivi inglese: At the end of the course, the student acquires the skills to survey and monitor transport infrastructures, from the project phase to the support for their management, using advanced geomatic techniques.						

6708 000 000 92871 - 0 - SUSTAINABLE AND INTEGRATED URBAN TRANSIT SOLUTIONS	ICAR/05	CEAR-03/B	6	48/0/0/0	No	Voto
			B			
<p><b>Ambito:</b>          Obiettivi: The course of Sustainable and Integrated Urban Transit Solutions aims to provide students with methodological, theoretical and empirical skills for planning, design, modelling, simulation and performance evaluation of integrated public transport systems in urban areas, with particular focus on sustainable mobility paradigms.</p> <p>Obiettivi inglese: The course of Sustainable and Integrated Urban Transit Solutions aims to provide students with methodological, theoretical and empirical skills for planning, design, modelling, simulation and performance evaluation of integrated public transport systems in urban areas, with particular focus on sustainable mobility paradigms.</p>						

6708 000 000 92868 - 0 - TRANSPORT SYSTEM DESIGN AND PLANNING	ICAR/05	CEAR-03/B	6	48/0/0/0	No	Voto
			B			
<p><b>Ambito:</b>          Obiettivi: The course of Transport Systems Design and Planning aims to provide students with the basic tools for simulation and functional design of transport systems, by modeling transport demand and supply and their interactions. Acquisition of specific knowledge is expected in order to address the typical problems in the perspective of transportation systems engineering, by providing deep knowledge in transport system modeling and simulation on the macro-, meso-, and microscopic level, supported by case studies and software tools.</p> <p>Obiettivi inglese: The course of Transport Systems Design and Planning aims to provide students with the basic tools for simulation and functional design of transport systems, by modeling transport demand and supply and their interactions. Acquisition of specific knowledge is expected in order to address the typical problems in the perspective of transportation systems engineering, by providing deep knowledge in transport system modeling and simulation on the macro-, meso-, and microscopic level, supported by case studies and software tools.</p>						

#### Gruppo: 4) Courses freely chosen by the student

#### TAF: D Ambito: 1008 - A scelta dello studente

**Cfu min: 12 Cfu max: 12**

Note: Choose at least 12 credits. The course board suggests to attend to the following courses:

Attività formativa	TIP	SSD	SSD 2024	TAF	CFU	ORE F/E/L/N	FREQ. VER.
6708 000 000 72803 - 0 - BIOTECHNOLOGY FOR THE SUSTAINABLE RECLAMATION OF CONTAMINATED LANDS AND WATERS		ICAR/03	CEAR-02/A		6	48/0/0/0	No Voto
			D				
<p><b>Ambito:</b>          Obiettivi: 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.</p> <p>Obiettivi inglese: 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.</p>							
6708 000 000 92872 - 0 - CIRCULAR-GREEN MANAGEMENT OF URBAN DRAINAGE		ICAR/02	CEAR-01/B		6	48/0/0/0	No Voto
			B				
<p><b>Ambito:</b> 206 - Ingegneria civile          Obiettivi: Al termine del corso lo studente possiede conoscenze sulle soluzioni tecniche e sulla loro progettazione nel contesto della gestione circolare delle risorse idriche. In particolare, lo studente approfondirà:</p> <ol style="list-style-type: none"> <li>1. Il concetto di gestione circolare delle risorse idriche;</li> <li>2. Il clima nel 21 ° secolo: analisi degli impatti dei cambiamenti climatici sulle risorse idriche;</li> <li>3. Progettazione degli eventi climatici estremi nelle aree urbane soggette a cambiamenti climatici;</li> <li>4. Teoria delle decisioni per la gestione circolare delle risorse idriche;</li> <li>5. Best management practices (BMP) per la gestione del drenaggio delle acque;</li> <li>6. Analisi costi-benefici per le BMP;</li> <li>7. Qualità delle acque superficiali e sotterranee;</li> <li>8. L'obiettivo del riciclo dell'acqua al 100% e le relative implicazioni sulle emissioni di CO2.</li> </ol> <p>Obiettivi inglese: At the end of the course, the student will have knowledge on technical solutions and their design in the context of circular water resources management. In particular, the student will focus on:</p> <ol style="list-style-type: none"> <li>1. The concept of circular water resources management;</li> <li>2. Climate in the 21st century: review of climate change impacts on water resources;</li> <li>3. Estimation of design storm in urban areas under climate change and non-stationarity;</li> <li>4. Decision theory for circular water resources management;</li> </ol>							

5. Best management practices (BMP) for drainage management;
6. Cost-benefit analysis for BMPs;
7. Surface and groundwater quality;
8. The target of 100% water recycling and implications on CO2 emissions.

6708 000 000 95709 - 0 - CLIMATE CHANGE ADAPTATION	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p><b>Obiettivi:</b> Students of this course will learn solutions to climate change adaptation and their technical design, by focusing on extreme weather events - in particular floods and droughts - low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as an effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design.</p> <p>The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent re-search developments and will make use of open access information.</p> <p><b>Obiettivi inglese:</b> Students of this course will learn solutions to climate change adaptation and their technical design, by focusing on extreme weather events - in particular floods and droughts - low carbon management of climate hazards, and innovative strategies and interventions for the mitigation of climate change impact. Risk based adaptation design and decision theory will be considered as an effective and transparent means to evaluate competitive solutions and assign priorities, while uncertainty assessment will provide the basis for a pragmatic design.</p> <p>The joint analysis and modeling of solutions and societal systems will be the driving concept of the course, with an evolving educational path that will focus on the most recent re-search developments and will make use of open access information.</p>						
6708 000 000 72769 - 0 - COMPUTATIONAL MECHANICS	ICAR/08	CEAR-06/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b></p> <p><b>Obiettivi:</b> The Computational Mechanics course aims to provide students with the knowledge of the finite element method for solid and structural mechanics problems. Through this course, students will gain the theoretical and practical skills necessary to develop and implement the finite element method for a wide range of structural engineering problems and critically analyse the results. There is a strong emphasis on the computer implementation of algorithms in programming assignments. The application to real engineering problems is stressed throughout the course.</p> <p><b>Obiettivi inglese:</b> The Computational Mechanics course aims to provide students with the knowledge of the finite element method for solid and structural mechanics problems. Through this course, students will gain the theoretical and practical skills necessary to develop and implement the finite element method for a wide range of structural engineering problems and critically analyse the results. There is a strong emphasis on the computer implementation of algorithms in programming assignments. The application to real engineering problems is stressed throughout the course.</p>						
6708 000 000 B8646 - 0 - DESIGN OF NATURE-BASED SOLUTIONS FOR SUSTAINABLE URBAN MOBILITY	AGR/10	AGRI-04/C	6	48/0/0/0	No	Voto
D						
<p><b>Ambito:</b> 1008 - A scelta dello studente</p> <p><b>Obiettivi:</b> At the end of the course, the student acquires theoretical knowledge and application skills on the design of nature-based solutions and green systems – integrated or coupled with infrastructures for urban mobility – aimed at increasing resiliency and mitigating the main environmental impacts in the urban areas (rainwater management and heat island effect). Furthermore, depending on the type of infrastructure, the student can identify the most suitable nature-based solutions, size and design them while assessing their environmental mitigation effects, considering flood/drought periods, functional performance, quality and the sustainability in the materials, design, construction and maintenance phases.</p> <p><b>Obiettivi inglese:</b> At the end of the course, the student acquires theoretical knowledge and application skills on the design of nature-based solutions and green systems – integrated or coupled with infrastructures for urban mobility – aimed at increasing resiliency and mitigating the main environmental impacts in the urban areas (rainwater management and heat island effect). Furthermore, depending on the type of infrastructure, the student can identify the most suitable nature-based solutions, size and design them while assessing their environmental mitigation effects, considering flood/drought periods, functional performance, quality and the sustainability in the materials, design, construction and maintenance phases.</p>						
6708 000 000 92870 - 0 - DESIGN, MONITORING AND MANAGEMENT OF AIRPORT AND RAILWAY	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
B						
<p><b>Ambito:</b> 206 - Ingegneria civile</p> <p><b>Obiettivi:</b> Al termine del corso lo studente conoscerà i temi relativi alla progettazione di una infrastruttura ferroviaria dal punto di vista geometrico e strutturale; alla progettazione delle pavimentazioni, la geometria, la segnaletica e le infrastrutture di servizio "air side" per le infrastrutture aeroportuali. Sarà sviluppato anche il tema delle connessioni tra i diversi mezzi di trasporto in ambito urbano con particolare riferimento alla multimodalità connessa all'accessibilità dei nodi.</p> <p><b>Obiettivi inglese:</b> At the end of the course, the student will learn topics related to the design of a railway infrastructure from a geometric and structural point of view; topics related to the design of the pavements, the geometry, the signs and the "air side" service for the airport infrastructures will be treated. The theme of the connections between the various mode of transport in urban area will also be developed with particular reference to the multimodality and the accessibility of the nodes.</p>						

6708 000 000 72805 - 0 - ENGINEERING GEOLOGY	GEO/05	GEOS-03/B	6	48/0/0/0	No	Voto
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**Ambito:**

D

Obiettivi: Engineering Geology explores engineering and environmental challenges stemming from interactions between geology and human activities, aiming to build understanding of geological processes and their impact on engineering design.

Upon successful completion of this course, students will be able to:

Analyze Geological Processes: Demonstrate a comprehensive understanding of geological and geomorphological processes, assessing their implications for engineering and environmental projects.

Interpret Geological Data: Critically analyze and interpret geological data from various sources, including maps and site investigation reports, to make informed engineering geological decisions.

Assess Geological Hazards: Evaluate geological hazards, with a focus on mass movements, and develop geological models to inform engineering decisions.

Develop Preventive and Remedial Measures: Formulate strategies to prevent and mitigate the impacts of geological hazards, with a focus on mass movements, including recommendations for site-specific interventions.

Collaborate with Multidisciplinary Teams: Communicate effectively with professionals across disciplines, contributing geological insights to multidisciplinary engineering and environmental design.

Obiettivi inglese: Engineering Geology explores engineering and environmental challenges stemming from interactions between geology and human activities, aiming to build understanding of geological processes and their impact on engineering design.

Upon successful completion of this course, students will be able to:

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Interpret Geological Data: Critically analyze and interpret geological data from various sources, including maps and site investigation reports, to make informed engineering geological decisions.

Assess Geological Hazards: Evaluate geological hazards, with a focus on mass movements, and develop geological models to inform engineering decisions.

Develop Preventive and Remedial Measures: Formulate strategies to prevent and mitigate the impacts of geological hazards, with a focus on mass movements, including recommendations for site-specific interventions.

Collaborate with Multidisciplinary Teams: Communicate effectively with professionals across disciplines, contributing geological insights to multidisciplinary engineering and environmental design.

6708 000 000 78594 - 0 - FLOOD AND DROUGHT RISK MANAGEMENT	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
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**Ambito:**

B

Obiettivi: The objective of this course is to provide students with the understanding of the factors causing floods and droughts and with the knowledge both of the methods for quantifying and of the options for reducing such water risks. By the end of the course, students have the knowledge of the data requirement and methods used for the assessment of river flood and drought risk, in terms of hazard, exposure and vulnerability.

Students will also learn about the measures available for mitigating and managing such risks (such as structures for flood defense, flood and drought policies/plans/mapping; forecasting and warning systems).

Applied skills: through the development of the assignments, students will apply their knowledge to obtain and process their own real-world meteo-hydrological data and to use them for i) computing meteorological and hydrological drought indicators and ii) estimating design floods.

Obiettivi inglese: The objective of this course is to provide students with the understanding of the factors causing floods and droughts and with the knowledge both of the methods for quantifying and of the options for reducing such water risks. By the end of the course, students have the knowledge of the data requirement and methods used for the assessment of river flood and drought risk, in terms of hazard, exposure and vulnerability.

Students will also learn about the measures available for mitigating and managing such risks (such as structures for flood defense, flood and drought policies/plans/mapping; forecasting and warning systems).

Applied skills: through the development of the assignments, students will apply their knowledge to obtain and process their own real-world meteo-hydrological data and to use them for i) computing meteorological and hydrological drought indicators and ii) estimating design floods.

6708 000 000 B5516 - 0 - GEOMATICS FOR GIS	ICAR/06	CEAR-04/A	6	48/0/0/0	No	Voto
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**Ambito:**

206 - Ingegneria civile

B

Obiettivi: Il corso approfondisce l'uso dei Sistemi Informativi Geografici (GIS) e le moderne tecnologie offerte dalla Geomatica per la raccolta, la gestione e l'analisi dei dati geospaziali. Gli studenti acquisiscono consapevolezza delle potenzialità e dei limiti delle tecniche di rappresentazione metrica del territorio o di specifiche infrastrutture, specialmente in termini di accuratezza e produttività, e apprendono come sceglierle ed integrarle per supportare diverse applicazioni dell'ingegneria ambientale e civile.

Obiettivi inglese: The course provides insights into the use of Geographical Information Systems (GIS) and the modern technologies offered by Geomatics to collect, manage and analyse geospatial data. Students gain awareness on potentials and limitations of the techniques for the metric representation of the landscape or of specific infrastructures, especially in terms of accuracy and productivity, and learn how to choose and integrate them to support different environmental and civil engineering applications.

6708 000 000 78593 - 0 - GROUNDWATER AND CONTAMINATION PROCESSES	ICAR/01	CEAR-01/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 206 - Ingegneria civile			B			
<p>Obiettivi: The course provides fundamentals of subsurface flow and transport, emphasizing the primary role of groundwater in the hydrologic cycle, the relation of groundwater flow to hydrogeological properties, and the management of contaminated groundwater. Effective methods for the prediction and interpretation of groundwater processes will be discussed together with engineering implications. These include basics of infrastructure design related to the subsurface environment. Particular attention will be reserved to well hydraulics having several implications in water exploitation, monitoring and remediation. Description and analysis of both synthetic and real case studies will provide the opportunity to jointly apply concepts and methods discussed during the course.</p> <p>Obiettivi inglese: The course provides fundamentals of subsurface flow and transport, emphasizing the primary role of groundwater in the hydrologic cycle, the relation of groundwater flow to hydrogeological properties, and the management of contaminated groundwater. Effective methods for the prediction and interpretation of groundwater processes will be discussed together with engineering implications. These include basics of infrastructure design related to the subsurface environment. Particular attention will be reserved to well hydraulics having several implications in water exploitation, monitoring and remediation. Description and analysis of both synthetic and real case studies will provide the opportunity to jointly apply concepts and methods discussed during the course.</p>						
6708 000 000 95813 - 0 - LARGE-SCALE WATER STRUCTURES	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto
<b>Ambito:</b>			B			
<p>Obiettivi: Students will learn advanced theoretical concepts and operational tools for the design of large-scale water structures, including dams, reservoirs and hydro-power systems. Students will gain expertise on the hydraulic and management challenges of large-scale water structures and their environmental impact. Students will be able to check dam stability, design key hydraulic facilities and large-scale hydro-power plants. Case studies related to recently built water structures will be examined.</p> <p>Obiettivi inglese: Students will learn advanced theoretical concepts and operational tools for the design of large-scale water structures, including dams, reservoirs and hydro-power systems. Students will gain expertise on the hydraulic and management challenges of large-scale water structures and their environmental impact. Students will be able to check dam stability, design key hydraulic facilities and large-scale hydro-power plants. Case studies related to recently built water structures will be examined.</p>						
6708 000 000 78965 - 0 - PUBLIC PROCUREMENT	IUS/10	GIUR-06/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente			D			
<p>Obiettivi: The aim of the course is to give a complete survey of the juridical and judicial landscape of the Italian and European systems in the topic of public procurement and contract.</p> <p>Obiettivi inglese: The aim of the course is to give a complete survey of the juridical and judicial landscape of the Italian and European systems in the topic of public procurement and contract.</p>						
6708 000 000 92869 - 0 - ROAD INFRASTRUCTURE SUSTAINABLE AND SAFE MANAGEMENT	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente			B			
<p>Obiettivi: Lo studente del Corso di Road Infrastructure Sustainable and Safe Management affronterà i temi delle infrastrutture di trasporto in ambito urbano e metropolitano. Attraverso l'evoluzione delle infrastrutture stradali si giungerà al progetto della strada odierno con particolare riferimento alle sicurezza delle utenze deboli. Saranno illustrati gli aspetti legati al progetto della pavimentazione stradale in ambito urbano ed alla sua manutenzione. Tra le moderne soluzioni cittadine si proporranno i temi del riciclaggio dei materiali, della gestione dell'infrastruttura e delle linee di Trasporto Pubblico Locale.</p> <p>Obiettivi inglese: The student of the Road Infrastructure Sustainable and Safe Management Course will address the issues of transport infrastructure in urban and metropolitan areas. Through the evolution of the road infrastructures we will reach the project of today's road with particular reference to the safety of Vulnerable road users. The aspects related to the urban road pavement project and its maintenance will be illustrated. Among the modern city solutions the course will handle with the themes of material recycling, infrastructure management and Public Transport Infrastructure.</p>						
6708 000 000 78595 - 0 - ROAD SAFETY ENGINEERING	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
<b>Ambito:</b> 1008 - A scelta dello studente			D			
<p>Obiettivi: The objectives of the unit are to gain a clear understanding of:</p> <ul style="list-style-type: none"> <li>- why road safety is important, how we can achieve improvements and who is doing the work;</li> <li>- the multidisciplinary nature of road safety and why we need to use a combination of engineering, education and enforcement to be successful;</li> <li>- the behaviour of road users and ways in which the road environment can be designed/improved to cater for their needs;</li> <li>- the complexity of the human/vehicle/road system and how the interrelationships work to influence the level of safety;</li> <li>- what are the legal responsibilities of road authorities and decision makers and how they can fulfil them;</li> <li>- how to undertake accident investigations;</li> <li>- how to collect accident data and what to look for in quality data;</li> <li>- how to analyse accident data, turn it into information and develop cost effective, practical counter measures;</li> <li>- what needs to be done after treating a site and how to do it;</li> <li>- how to be proactive in preventing accidents before they occur.</li> </ul>						

Specific skill sets developed in the class are:

- Analysis of traffic collision and injury data;
- Analysis of collision risk in a road network (network screening);
- Identifying crash causal factors;
- Identifying and evaluating countermeasures;
- Principles of Road Safety Management.
- What is the Road safety Audit procedure, and what are aims and objectives, roles and responsibility; history of road safety audit, road safety audit and design standards, road safety audit tasks, various stages of safety audits; common identifiable problems.
- How to structure a road safety audit report, identify common problems.
- Case studies and site visit; what to look for on site visits.

Obiettivi inglese: The objectives of the unit are to gain a clear understanding of:

- why road safety is important, how we can achieve improvements and who is doing the work;
- the multidisciplinary nature of road safety and why we need to use a combination of engineering, education and enforcement to be successful;
- the behaviour of road users and ways in which the road environment can be designed/improved to cater for their needs;
- the complexity of the human/vehicle/road system and how the interrelationships work to influence the level of safety;
- what are the legal responsibilities of road authorities and decision makers and how they can fulfil them;
- how to undertake accident investigations;
- how to collect accident data and what to look for in quality data;
- how to analyse accident data, turn it into information and develop cost effective, practical counter measures;
- what needs to be done after treating a site and how to do it;
- how to be proactive in preventing accidents before they occur.

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- Identifying crash causal factors;
- Identifying and evaluating countermeasures;
- Principles of Road Safety Management.
- What is the Road safety Audit procedure, and what are aims and objectives, roles and responsibility; history of road safety audit, road safety audit and design standards, road safety audit tasks, various stages of safety audits; common identifiable problems.
- How to structure a road safety audit report, identify common problems.
- Case studies and site visit; what to look for on site visits.

6708 000 000 72807 - 0 - SCIENCE AND TECHNOLOGY OF COMPOSITE MATERIALS M	ING-IND/22	IMAT-01/A	6	48/0/0/0	No	Voto
<b>Ambito:</b>	1008 - A scelta dello studente					D
Obiettivi: Knowledge of properties, application and manufacturing technology of main composite materials. Comprehension of the mechanisms which allow to obtain particular properties on the basis of material components and their architecture. Ability in the choice of the most suitable composite material on the basis of the technological requirements of the product.						
Obiettivi inglese: Knowledge of properties, application and manufacturing technology of main composite materials. Comprehension of the mechanisms which allow to obtain particular properties on the basis of material components and their architecture. Ability in the choice of the most suitable composite material on the basis of the technological requirements of the product.						
6708 000 000 B6479 - 0 - SCIENCE OF CLIMATE CHANGE	ICAR/02	CEAR-01/B	6	48/0/0/0	No	Voto

**Ambito:** 1008 - A scelta dello studente

Obiettivi: Students will learn what knowledge is needed to identify solutions to climate change mitigation and adaptation. They will learn how climate change can be mitigated, how adaptation may be carried out and how mitigation and adaptation interact each other. Students will learn what we know and what we still do not know about climate and climate change. They will also know what contribution they can give to resolve the climate challenge in both their roles of citizens and experts. The involved disciplines are: climate dynamics, climate analysis and modelling, geo-environmental sciences and water cycle, climate engineering and environmental engineering. The approach will be interdisciplinary with the aim to move to transdisciplinarity, namely, by setting the basis for an innovative scientific and technical approach.

Obiettivi inglese: Students will learn what knowledge is needed to identify solutions to climate change mitigation and adaptation. They will learn how climate change can be mitigated, how adaptation may be carried out and how mitigation and adaptation interact each other. Students will learn what we know and what we still do not know about climate and climate change. They will also know what contribution they can give to resolve the climate challenge in both their roles of citizens and experts. The involved disciplines are: climate dynamics, climate analysis and modelling, geo-environmental sciences and water cycle, climate engineering and environmental engineering. The approach will be interdisciplinary with the aim to move to transdisciplinarity, namely, by setting the basis for an innovative scientific and technical approach.

6708 000 000 92867 - 0 - SURVEY AND MONITORING OF TRANSPORT INFRASTRUCTURES	ICAR/06	CEAR-04/A	6	48/0/0/0	No	Voto
B						
<b>Ambito:</b> 206 - Ingegneria civile						
Obiettivi: Al termine del corso, con il conseguimento dei crediti formativi, lo studente possiede le competenze necessarie al rilievo e monitoraggio delle infrastrutture di trasporto, dal progetto al supporto per la loro gestione, mediante tecniche geomatiche avanzate.						
Obiettivi inglese: At the end of the course, the student acquires the skills to survey and monitor transport infrastructures, from the project phase to the support for their management, using advanced geomatic techniques.						
6708 000 000 72748 - 0 - SUSTAINABILITY IN CONSTRUCTION	ICAR/09	CEAR-07/A	6	48/0/0/0	No	Voto
B						
<b>Ambito:</b> 206 - Ingegneria civile						
Obiettivi: Course overview, introduction to sustainability. Definitions, trends, measurements. Aspects on sustainability (environmental, economic, social). Environmental footprint of engineered systems, with emphasis on civil engineering (energy consumptions, CO2 emissions, etc). Performance-based design and life-cycle planning. The various aspects to be considered for sustainability in construction: material's production and transformation, management of construction process, occupancy (use costs energy and cost consumptions), occupancy (maintenance and durability issues), end-of-life costs, reuse/recycling. Life-cycle analysis (LCA): Cradle-to-grave analysis, LCA as a min-max problem. Mathematical tools required (Optimization techniques, multi-criteria decision making methods, simulation methods, statistics). Social Life Cycle Assessment (S-LCA) and Ecologically based LCA (Eco-LCA). Safety as a prerequisite. Energy efficiency in buildings. Renewable energy with emphasis to building applications (solar thermal and photovoltaic energy, geothermal energy). Protocols for rating systems for the design, construction and operation of high performance green buildings (LEED system, Ithaca).						
Obiettivi inglese: Course overview, introduction to sustainability. Definitions, trends, measurements. Aspects on sustainability (environmental, economic, social). Environmental footprint of engineered systems, with emphasis on civil engineering (energy consumptions, CO2 emissions, etc). Performance-based design and life-cycle planning. The various aspects to be considered for sustainability in construction: material's production and transformation, management of construction process, occupancy (use costs energy and cost consumptions), occupancy (maintenance and durability issues), end-of-life costs, reuse/recycling. Life-cycle analysis (LCA): Cradle-to-grave analysis, LCA as a min-max problem. Mathematical tools required (Optimization techniques, multi-criteria decision making methods, simulation methods, statistics). Social Life Cycle Assessment (S-LCA) and Ecologically based LCA (Eco-LCA). Safety as a prerequisite. Energy efficiency in buildings. Renewable energy with emphasis to building applications (solar thermal and photovoltaic energy, geothermal energy). Protocols for rating systems for the design, construction and operation of high performance green buildings (LEED system, Ithaca).						
6708 000 000 92871 - 0 - SUSTAINABLE AND INTEGRATED URBAN TRANSIT SOLUTIONS	ICAR/05	CEAR-03/B	6	48/0/0/0	No	Voto
B						
<b>Ambito:</b>						
Obiettivi: The course of Sustainable and Integrated Urban Transit Solutions aims to provide students with methodological, theoretical and empirical skills for planning, design, modelling, simulation and performance evaluation of integrated public transport systems in urban areas, with particular focus on sustainable mobility paradigms.						
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6708 000 000 78737 - 0 - SUSTAINABLE BUILDING DESIGN	ICAR/10	CEAR-08/A	6	48/0/0/0	No	Voto
D						
<b>Ambito:</b> 1008 - A scelta dello studente						
Obiettivi: The Training Objectives of the SUSTAINABLE BUILDING DESIGN course is to deliver knowledge for future construction managers and designers on the: i) optimization of site potential; optimization of energy use; optimize building spaces and material use. The course attenders will achieve design capabilities and skills within a total project context in order to achieve quality, high-energy performance up to nearly zero energy buildings (nZEBs).						
Obiettivi inglese: The Training Objectives of the SUSTAINABLE BUILDING DESIGN course is to deliver knowledge for future construction managers and designers on the: i) optimization of site potential; optimization of energy use; optimize building spaces and material use. The course attenders will achieve design capabilities and skills within a total project context in order to achieve quality, high-energy performance up to nearly zero energy buildings (nZEBs).						
6708 000 000 81509 - 0 - SUSTAINABLE ROAD INFRASTRUCTURES	ICAR/04	CEAR-03/A	6	48/0/0/0	No	Voto
B						
<b>Ambito:</b>						
Obiettivi: Students will be introduced to road engineering and learn how these transportation infrastructures are conceived. A range of different externalities will be addressed and evaluated in order to identify the possible sustainable approaches towards the design and construction of less impacting roads. Emerging topics such as territory fragmentation and soil-bio engineering will be imparted as possible multidisciplinary solutions for the novel civil engineer that will know how to evaluate the impact of a road infrastructure on the territory and how to design the interventions to mitigate these effects, for a more sustainable infrastructure.						
Obiettivi inglese: Students will be introduced to road engineering and learn how these transportation infrastructures are conceived. A range of different externalities will be addressed and evaluated in order to identify the possible sustainable approaches towards the design and construction of less impacting roads. Emerging topics such as territory fragmentation and soil-bio engineering will be imparted as possible multidisciplinary						

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6708 000 000 92868 - 0 - TRANSPORT SYSTEM DESIGN AND PLANNING

ICAR/05

CEAR-03/B

6

48/0/0/0

No

Voto

B

**Ambito:**

Obiettivi: The course of Transport Systems Design and Planning aims to provide students with the basic tools for simulation and functional design of transport systems, by modeling transport demand and supply and their interactions. Acquisition of specific knowledge is expected in order to address the typical problems in the perspective of transportation systems engineering, by providing deep knowledge in transport system modeling and simulation on the macro-, meso-, and microscopic level, supported by case studies and software tools.

Obiettivi inglese: The course of Transport Systems Design and Planning aims to provide students with the basic tools for simulation and functional design of transport systems, by modeling transport demand and supply and their interactions. Acquisition of specific knowledge is expected in order to address the typical problems in the perspective of transportation systems engineering, by providing deep knowledge in transport system modeling and simulation on the macro-, meso-, and microscopic level, supported by case studies and software tools.

**Legenda:**

CFU: crediti formativi universitari

TAF: tipologia attività formativa (A-di base; B-caratterizzanti; C-affini o integrative; F-ulteriori attività formative; D-a scelta autonoma dello studente; S- stages e tirocini presso imprese, enti pubblici o privati, ordini professionali; E-per la prova finale)

SSD: settore scientifico disciplinare

F/E/L/N: indica le ore Frontali/Esercitazioni/Laboratori/Ore di esercitazione e/o laboratorio tenute da non docenti

Freq.: segnala l'esistenza di un obbligo di frequenza

Ver.: indica la modalità di verifica del profitto finale

TIP.: indica la tipologia delle forme didattiche. Queste possono essere CON: convenzionali, E-L: in e-learning, MIX: miste, C/E: convenzionali e/o e-learning. Il corso di studio può definire annualmente una delle modalità.