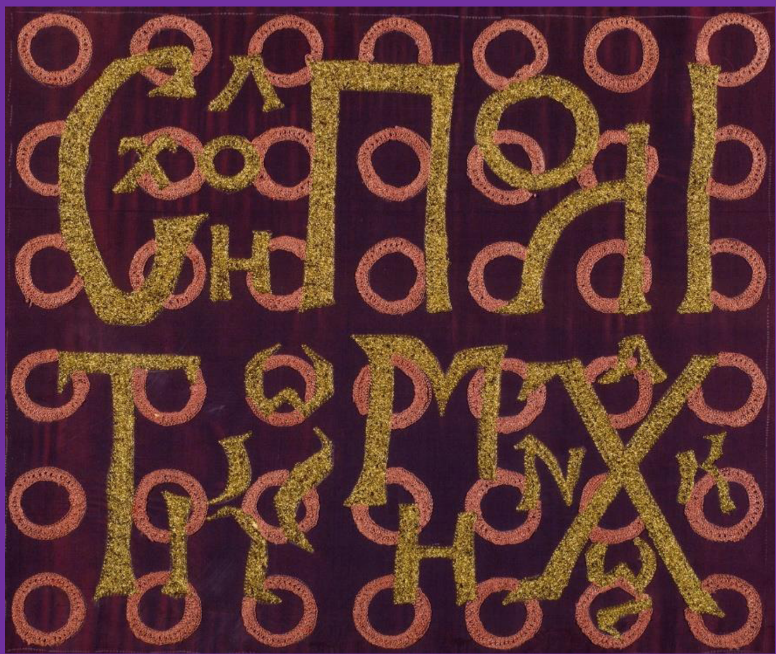
NATIONAL TECHNICAL UNIVERSITY OF ATHENS

SCHOOL OF CIVIL ENGINEERING

CURRICULUM GUIDE



ATHENS

Academic Year 2021-22

NATIONAL TECHNICAL UNIVERSITY OF ATHENS

SCHOOL OF CIVIL ENGINEERING

CURRICULUM GUIDE

ATHENS

ACADEMIC YEAR 2021-22

EDITION OF THE NATIONAL TECHNICAL UNIVERSITY OF ATHENS

SCHOOL OF CIVIL ENGINEERING

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Produced and edited by the Curriculum Committee of the School of Civil Engineering

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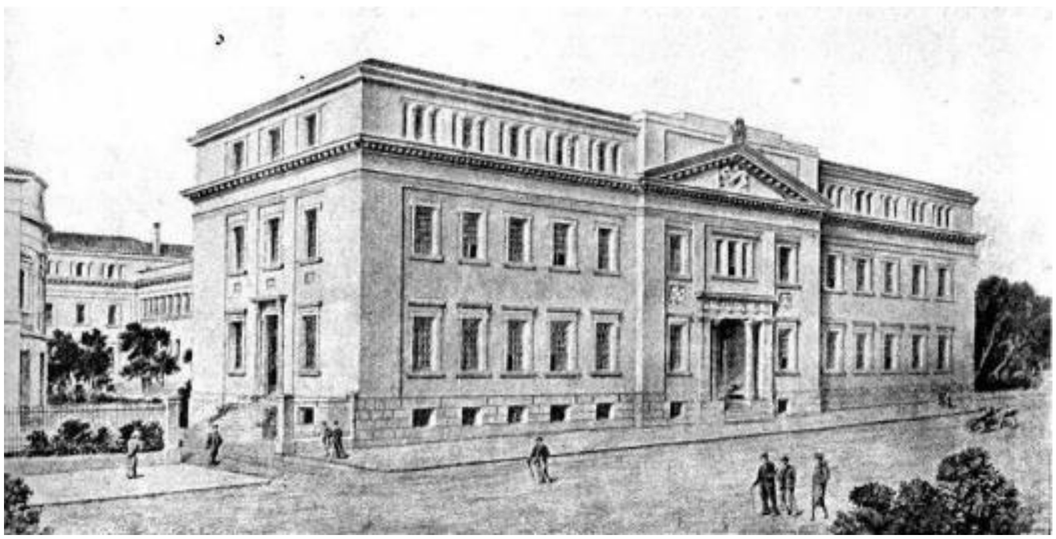
Preface

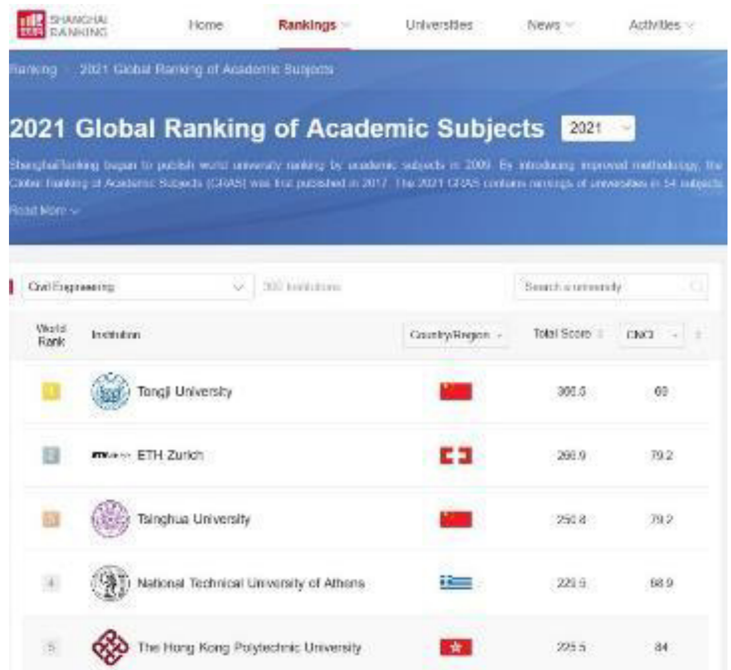
The School of Civil Engineering of the National Technical University of Athens is unique in Greece for both its past and present:

- It was the first Engineering School in the history of the country. Its foundation in 1887 marked the evolution of the Polytechnic from a craftsmen's school, to a higher academic institution. Throughout its history, the School has never ceased to operate even in the most difficult periods. The first 13 civil engineers graduated in 1890, and by 2017 when the School celebrated its 130th anniversary, 15,536 diplomas had been awarded.



Past and present. Upper: Perspective (from Stournari Street) of the Ghinis Building constructed between 1930-35, which housed the School of Civil Engineering for the remainder of the 20th century up until 2003. Lower: The new buildings of the School of Civil Engineering in the Zografou Campus, where the School is located from 2003.

- Today it is ranked as the top School in the country in terms of international recognition. As a result of the high quality of the work of its professors and students, undergraduate and postgraduate, the School is continuously placed very high in international rankings. It is the only university School in the country that has been included for years in the top 50 in the Quacquarelli Symonds (QS) world ranking list. This year, the 2021 Shanghai Ranking has ranked it 4th place in the world and 2nd in Europe, while in previous editions from 2017 it was ranked 7th in the world. For the first time in the history of international university rankings, a Greek school appears in the top five in the world. It is also important that the School also participates in interdepartmental subjects including water resources, transport technology and marine technology that have also been highly ranked by the recent Shanghai rankings.



With reference to both its past and present, but looking towards the future, in the academic year 2017-18, the School made significant changes to its curriculum. During the academic year 2020-21, the implementation of the new programme, which is reflected in this Curriculum Guide, was completed. The main principles of the new programme include:

- *Consistency to its 130-year history.* The School remains faithful to the objectives laid down in its founding principles: to prepare engineers "for public and private needs appropriate to the construction of roads, bridges, railways, hydraulic works and buildings". Over time, the technological nature of its curriculum remains a central and strategic choice.
- *Persistence to the standard of an integrated five-year study program*. The traditional model of integrated five-year studies leading to an integrated master's degree consistently corresponds to the strategic choices of both the School and the NTUA. This model has recently been established as a Law of the Greek State.
- *Balanced coexistence of theory and practice*. The School remains adamant in the traditional model of engineering education, providing a strong theoretical background, but also an integrated technological knowledge so that graduates are able to successfully handle real and demanding engineering problems

they may face. The School does not align itself with the international trend of providing a generalized scientific knowledge and skill set without deepening and without reference to the solving of specific real-world problems.

- *Balanced development of knowledge both in breadth and depth.* The objective of education in the broad field of civil engineering is served by a strong body of compulsory theoretical and technological courses. The objective of deepening of knowledge is accomplished through the operation of four distinct concentrations for specialized study during last semesters of studies. These include: structural, hydraulic, transportation and geotechnical engineering specialization. A group of specialized elective courses are offered to students of all concentrations to ensure the interaction and cooperation of students from different concentrations, while at the same time contributing to the goal of both a breadth and depth of knowledge.
- *New technological subjects.* The new curriculum further expands the subject of civil engineering with new technological courses in the regions of: use of information technology in engineering projects, new materials, renewable energy, new probabilistic/stochastic design methodologies, and risk analysis in projects and systems, both physical and artificial.
- *Emphasis on laboratory courses.* For the first time, compulsory, purely laboratory courses have been introduced into the School's program, one per year of study, namely: Materials in the first year, Construction and Geotechnical in the second, Water Resources in the third and Humanities in the fourth. These courses are conducted during both semesters in small groups of students (half in the winter and the other half in the spring semester), with mandatory attendance, but without the requirement of a final examination and score. In the fifth year, students can choose the two-month internship (regardless of concentration and without a final examination and score), while there is also an Integrated Design project (differentiated by concentration). The final semester of studies is devoted to the preparation and writing of a Diploma Thesis, which can be carried out in collaboration with one of the 15 Laboratories of the School.
- *Emphasis on active learning.* The new programme has reduced the teaching hours of passive learning, giving greater weight to active learning through exercises and subjects prepared by students, with appropriate guidance from the teaching staff.
- *Decrease in the number of courses and final exams.* With the new curriculum, the rule of six courses per semester of study was introduced for the first time in the history of the School, whereas in the past this number was seven and sometimes eight courses. This reduces the total number of courses for obtaining the diploma and the corresponding number of examinations, to the benefit of active educational procedures.
- *A compact timetable.* The development of the curriculum, and in particular the grouping of selection courses in such a way that each student chooses a single course from a specific group of elective courses, has allowed the creation of a more compact timetable. Teaching activities end in the early afternoon, having excluded the requirement for evening classes. During these evening hours, the classrooms remain open either for the use by students in order to study and prepare their works, or for the organization of informal educational events.

The new curriculum achieves, on the one hand, the promotion of a wide range of civil engineering fields and, on the other hand, the development of all those links between the individual subjects that ensure coherence and the universality of learning. The Greek society is still learning the wide range of civil engineering activities, which are no longer represented only by the traditional activity of building construction. The School has a duty to educate society in regard to the multitude of the professional fields and the corresponding prospects for its graduates.

On the contrary, within the international arena, as shown by the global evaluation of the School and the recent (March-June 2021) evaluation of the School by a committee of professors from abroad, the efforts and performance of the School for the whole range of civil engineering activities have been recognized. The Evaluation Committee's report was highly positive and concluded that the School is fully compliant with the accreditation criteria of its curriculum. Thus, after the legal recognition in 2018 that the Diploma of Civil Engineering of the NTUA constitutes an integrated master's degree, in 2021 the National Higher Education Authority, following the Evaluation Report, granted Accreditation of the School's curriculum as being in full compliance with the principles of the relevant Quality Standard for the level 7 of the National and European Qualifications Framework.

The modern technological and professional fields, which are taught in the School include the redesign, maintenance, reinforcement, renewal and management of existing structures and infrastructures. New challenges include the development and application of new materials and techniques in construction, the use of renewable energy sources, the protection against natural hazards (earthquakes, floods, droughts), the protection of the environment, the restoration and upgrading activities in conjunction with anti-pollution technology, as well as the use of information technology and smart devices both for more efficient construction management and operation of infrastructure. The balanced coexistence of development with the natural environment, and the promotion and preservation of cultural heritage are of particular importance in today's circumstances.

The professional areas of graduates' activity cover the whole of Greece. The School and its graduates remain closely linked to the development needs of the country. Despite significant progress in infrastructure projects in recent years, we are still in the process of completing a fully modernized infrastructure framework. Delays remain in the development of rail networks, large dams and hydroelectric projects, land improvement and flood defence. However, the area of activity is not geographically limited to within Greece. Notably, in amidst of the crisis in Greece, the extroverted nature of the School's graduates has been shown, by their achieving advancements to their professional prospects, as well as increased international recognition.

Moreover, the breadth and depth of studies at the School allows many of its graduates to work in research fields. A considerable number of its graduates are employed in teaching positions throughout the world, in both technological and theoretical subject areas. Of course, negative aspects of the crisis have significantly affected the School, which is unable to comprehensively and fully maintain and upgrade its infrastructure. Beyond this it is inhibiting the School from renewing and enriching its staff. Nevertheless, the School still envisions an optimistic future for itself, its staff and its graduates, and works fully toward this goal.

Athens, June 2021

Demetris Koutsoyiannis
Professor & Coordinator of the Curriculum Committee

Nikolaos Lagaros
Professor & Dean

Past and present. Upper: 10 of the first 13 students of the School who graduated in 1890. Lower: undergraduate and postgraduate students together with professors of the School at the European Geosciences Union conference in Vienna in 2018.

1 Structure and Activities of the School

1.1 General

The School of Civil Engineering of the National Technical University of Athens, the oldest engineering School in the country and alma mater to all other engineering schools, has played a protagonist role in the scientific, technical and economic development of the country during its many years of operation. Since the 19th century, in both turbulent and tranquil times during recent Greek history, the School's graduates have been a solid reference and a foundation of the construction and reconstruction of the country and its infrastructure. The School's graduates are not limited by the borders of the country and often leave their mark on world scientific and technological developments. Teaching staff and students actively participate in the global production of new knowledge.

The School consist of four departments, each of which is a separate unit for the production and dissemination of science and technology. More specifically these are:

- Department of Structural Engineering
- Department of Water Resources and Environmental Engineering
- Department of Transportation Planning and Engineering
- Department of Geotechnical Engineering

The School participates in various **postgraduate programs** that are co-organized by the NTUA's nine Schools. Two of these operate under the administrative responsibility of the School of Civil Engineering in the subjects of **Analysis and Design of Earthquake Resistant Structures** and **Water Resources Sciences and Technology**.

The School employs 47 professors and lecturers, 32 special teaching and research associates and 41 members for the administrative staff. The Schools departments, laboratories and the postgraduate programs are active both in educational and research activities, which are carried out in the context of diploma and postgraduate theses, doctoral theses and national, European and International research projects. The latter are closely connected to the overall educational efforts as a whole of the School, which are reinforced in this manner by additional specialized research personnel. The educational and research needs of the School are carried out in facilities spread out over approximately 40.000 m², the majority of which are part of the School's laboratories. Also, the School operates the Personal Computer Laboratory (PC-Lab) with the aim of a substantial and in-depth integration of Computer Science and Informatics in the study system, emphasizing the use of new digital technologies applied in the design, execution, operation and management of technical projects.

1.2 Departments

1.2.1 Department of Structural Engineering

The Department of Structural Engineering is active in the areas of theoretical and experimental statics, dynamics, structural stability analysis, formation and design of metal structures, reinforced concrete structures, pre-stressed concrete, concrete technology, earthquake engineering and computer applications. It includes four Laboratories, which cover the corresponding scientific areas and activities covered by the Department. Following the merger with the Department of Construction Engineering and Management, it also the responsibility for instruction of students in the management of technical works, throughout their lifecycle, from the conception of their necessity, until their delivery, operation and maintenance. It includes five Laboratories, which cover the corresponding scientific areas and activities covered by the Department. The laboratories are:

- Laboratory of Reinforced Concrete
- Laboratory of Steel Structures
- Laboratory of Earthquake Engineering
- Laboratory for Structural Analysis and Antiseismic Research
- Laboratory of Construction Equipment and Project Management

1.2.2 Department of Water Resources and Environmental Engineering

The Department of Water Resources and Environmental Engineering's main scientific areas are related to both the qualitative and quantitative aspects of the aquatic environment and related Civil Engineering works. It covers the educational and research areas of Fluid Mechanics, Hydrology, Water Resources, Hydraulic Works and more specifically Water Supply, Land Improvement Works (Irrigation, Drainage, Treatment), Flood Protection Works and Environmental and Sanitary Technology, Marine Hydraulics and Port Works, Energy and Hydroelectric Works. It includes four Laboratories, which cover the corresponding scientific areas and activities covered by the Department. The laboratories are:

- Laboratory of Applied Hydraulics
- Laboratory of Harbour Works
- Laboratory of Sanitary Engineering
- Laboratory of Hydrology and Water Resources Development

1.2.3 Department of Transportation Planning and Engineering

The Department of Transportation Planning and Engineering educationally and for research covers the transport of people and goods by all means, through all stages from research, general planning, feasibility studies until implementation, construction and operational studies. The Departments laboratories are utilized both for education, exercises, diploma and doctoral theses, as well as for the significant research activities entrusted to the Department by various entities both within Greece and internationally. The latter are closely connected to the overall educational efforts as a whole of the Department, which are reinforced in this manner by additional specialized research personnel. It includes three Laboratories, which cover the corresponding scientific areas and activities covered by the Department. The laboratories are:

- Laboratory of Traffic Engineering
- Laboratory of Pavement Engineering
- Laboratory of Railways and Transport

1.2.4 Department of Geotechnical Engineering

The Department of Geotechnical Engineering covers a wide range of known areas that include amongst others the study of soil behaviour under static and dynamic loading conditions, the behaviour of rock and geological formations, and the seismic behaviour of underground structures, dockside breakwaters and bridge pedestals. In addition, it covers the calculation, design and construction of foundation works and the protection and restoration of the geo-environment. It includes two Laboratories, which cover the corresponding scientific areas and activities covered by the Department. The laboratories are:

- Laboratory of Soil Mechanics
- Laboratory of Foundations Engineering

1.3 Laboratories

1.3.1 Laboratory of Reinforced Concrete

It was initially founded in 1918 and formally established in 1955. The activities of the Laboratory are devoted to the study of behaviour and design of materials and structures (buildings and infrastructure) made of reinforced concrete, masonry and timber, under various actions. More specifically, the Laboratory is active in the following scientific fields:

- Technology of concrete and durability
- Development of new cements and concretes for specific applications and of high performance
- Seismic behaviour and design of bearing elements and subassemblies made of reinforced concrete, masonry (modern and historical) and timber
- Documentation and assessment of existing reinforced and masonry structures (monuments, bridges)
- Interventions to existing structures and documentation of their efficiency
- Application of NDTs for in situ documentation of structures
- Numerical modelling and comparison between analytical and experimental or in situ behaviour

Laboratory of Reinforced Concrete

1.3.2 Laboratory of Steel Structures

It was established in 1965 and was officially integrated into NTUA’s Department of Civil Engineering in 1983. The Laboratory’s domain is the study of behaviour, conception, analysis, design and assessment of steel and composite civil engineering works, such as buildings, bridges, special/unconventional steel structures and steel products and systems. The range of the Laboratory’s fields of scientific activity includes:

- Design of novel seismic protection systems
- Design of steel structures for production and transportation of energy, such as wind turbines, towers and masts, pipelines and photovoltaic support systems
- Condition assessment and strengthening of existing structures
- Risk assessment with emphasis on seismic risk and resilience
- Design and optimization of industrial storage systems
- Study of structure-fluid interaction problems with emphasis on the effects of wind, fire and blast
- Investigation of structural failures and forensic engineering
- Simulation and optimization of industrial fabrication processes of steel components

The research activities include laboratory testing, field measurements, advanced numerical analyses and risk assessment studies.

Laboratory of Steel Structures

1.3.3 Laboratory for Earthquake Engineering

It was established in 1981. The Objective of the Laboratory is the study of the effects of earthquakes and vibrations on structures. The experimental research activities of the Laboratory include:

- Experiments for the investigation of the behaviour of all types of structures under dynamic and seismic loading, packaging systems, storage racks, vehicles, suspensions, supports, seismic isolation, museum exhibits and exterior shell glazing (curtain walls) for buildings, for design of new structures and rehabilitation of ancient and historical structures by seismic testing
- Hybrid testing using the Shaking Table for the investigation of soil-structure interaction
- Experiments for monitoring the behaviour of axle bearings on ships. Development of a monitoring system
- In situ measurements on structures, road and rail bridges for the determination of their dynamic characteristics
- In situ measurements of masonry modulus of elasticity using flat jack
- Analytical and numerical research activities using deterministic or stochastic methods on the seismic behaviour of structure
- Seismic hazard assessment in Greece using probabilistic analysis

Laboratory for Earthquake Engineering – Earthquake Simulator in front of the Reaction Wall

1.3.4 Laboratory for Structural Analysis and Antiseismic Research

It was initially founded in 1917 and formally established in 1962. The Laboratory for Structural Analysis and Aseismic Research (ISAAR) delivers interdisciplinary teaching and research in structural engineering, computational mechanics, and probabilistic engineering mechanics. Its vision is the development of innovative computational and structural solutions to enable future cities with niche capabilities that will allow them to operate within an ever-changing and adverse natural environment. Its interdisciplinary research agenda spans across both fundamental and applied research and aligns with the following research priority areas:

- Development of novel numerical simulation methods for the static, dynamic and seismic behaviour of structures
- Development of software for the analysis and design of structures
- Limit state analysis of materials and structures
- Multiscale analysis of composite materials and structures
- Structural optimization and stochastic structural analysis

Building of the Laboratory for Structural Analysis and Antiseismic Research

1.3.5 Laboratory of Construction Equipment and Project Management

It was initially founded in 1983 and formally established in 2002. The laboratory deals with construction equipment and methods in terms of cost, time, quality, safety, risk and human factors and with the synthesis of the separate activities for the management of construction projects. In particular, the laboratory is active in the following fields:

- Demonstration of mechanical components and systems of construction equipment.
- Design & provision of project management services.
- Productivity measurement systems of construction equipment.
- Analysis and development of computer software for construction equipment & project management
- Arbitration of construction disputes
- Participation in relevant funded or co-funded projects
- Organization of relevant conferences & workshops
- Certification in project management (PMGCert)

Activities of the Laboratory of Construction Equipment and Project

1.3.6 Laboratory of Applied Hydraulics

It was established in 1962. Basic and applied research: Computational (CFD) and experimental via theses or funded research projects. Also, specialized services to Ministries, water authorities & consulting/ construction companies. Main research areas are:

- Environmental Fluid Mechanics. Mathematical models of (1) flood hydrodynamics and inundation, (2) hydrodynamic behaviour and water quality of rivers, lakes, reservoirs, coastal waters, artificial islands, and aquacultures, (3) effluent, cooling waters, and brine disposal, (4) oil slick behaviour, (5) water and wastewater treatment units, (6) indoor environment etc. Investigation of climate change effects.
- Eco-Hydraulics. Mathematical models in rivers for (1) hydrodynamic - habitat, (2) fish behaviour - fish passes, (3) vegetation effects etc.
- Open Channel Flow And Hydraulic Structures. Physical and numerical modelling (1) for the optimal design and operation of hydraulic structures such as dam spillways stilling basins, junctions, (2) in channel transitions, compound channel sections, drops, weirs and sluice gates, vegetated channels, (3) dam break flows, (4) flows around bridge piers, (5) sediment transport etc.
- Geoevironmental Technology & Groundwater Hydraulics. Modelling of groundwater flow and pollution in aquifers; contaminated soil remediation; hazardous waste management.

Laboratory of Applied Hydraulics

1.3.7 Laboratory of Harbour Works

It was established in 1965. The domain of the Laboratory is the study of marine processes, the design and management of port, coastal and offshore infrastructure, and the management of marine and coastal areas. In particular, the laboratory is active in fundamental and applied research in the following scientific fields:

- Marine Hydraulics, Coastal Engineering, Harbour Works, Inshore and Offshore Structures, Coastal Protection, Complex Breakwater for wave-energy conversion.

- Physical and numerical modelling of harbours, inshore and offshore infrastructure, coastal processes, wave action, morphological bed evolution, waves-structures interaction.
- Integrated Coastal Zone Management (ICZM) and Marine Spatial Planning (MSP).
- Monitoring and evaluation of harbour and coastal structures with modern methods including unmanned aerial vehicles,3-D cameras and ROVs.
- Coastal Inundation Integrated Modelling, and development of seaports and coastal structures' vulnerability indices.
- Coupling of oceanographic and atmospheric databases with state-of-the-art software to improve shipping conditions.

Laboratory of Harbour Works

1.3.8 Laboratory of Sanitary Engineering

It was established in 1981 and was officially integrated into NTUA's Department of Civil Engineering in 1982. The activities of the Laboratory include education, basic and applied research and consultancy services in the wider field of Water Resources Management and Environmental Protection. The research covers both fundamental and applied research in the following specific fields:

- Management of water resources
- Drinking water treatment, wastewater and sludge treatment
- Solid waste management
- Sludge and wastewater reuse
- Nutrients and energy recovery from waste
- Quality of aquatic environment

- Fate of priority pollutants and emerging contaminants in wastewater treatment systems and in the aquatic environment
- Mathematical modelling of biological processes
- Bioremediation
- Ecosystems and environmental impact assessments

Laboratory of Sanitary Engineering

1.3.9 Laboratory of Hydrology and Water Resources Development

It was established in 1998. The domain of the Laboratory is the study of hydrological processes, the management of water resources, and the design and management of hydraulic infrastructure. In particular, the laboratory is active in the following scientific fields:

- Analysis and simulation of hydrometeorological and climatic processes, and quantification of their uncertainty.
- Analysis of extreme hydrological phenomena (floods, droughts) and study of hydraulic works for protection from them.
- Methodologies for design and holistic management of hydrosystems and renewable energy systems.

- Design, management and optimization of urban water systems and infrastructure - Hydroinformatics applications.
- Measuring networks, telemetry and databases for hydrological and meteorological information.
- Development of stochastic simulation and forecast models, optimization algorithms and decision support tools.
- Technology of ancient hydraulic works and studies for their promotion.

Laboratory of Hydrology and Water Resources Development – Field research

1.3.10 Laboratory of Pavement Engineering

It was established in 1962. The domain of the Laboratory is the design, construction, maintenance, reinforcement and management of road and airfield pavements and special issues of railway infrastructure materials. The Laboratory consists of two Units, the “Laboratory Unit for Testing and Characterization of Materials and Mixtures” (Unit 1) and the “Unit of Mobile Measurement and Monitoring Systems” (Unit 2). It is active in the following scientific fields:

- Laboratory determination of fundamental properties and mechanical characteristics of unbound materials, binders and mixtures of pavements (laboratory).
- Evaluation of alternative and / or recyclable materials for use in construction, maintenance and reconstruction of pavements.
- In-situ assessment of bearing capacity of mixtures and performance of road and airfield pavements using Non-Destructive Testing (NDT) systems on a 1:1 scale.
- Development and operation of a Pavement Monitoring System (PMS).

Laboratory of Pavement Engineering - Laboratory Unit for Testing and Characterization of Materials and Mixtures (left), Unit of Mobile Measurement and Monitoring Systems (right)

1.3.11 Laboratory of Railways and Transport

It was initially founded in 1962 and formally established in 1983. The domain of the Laboratory is the study of the design and operation of aspects of transport systems and terminals, with an emphasis on rail, port facilities, airports, combined transport and logistics. In particular, the laboratory is active in the following scientific fields:

Design and operation of transport systems (Transportation Systems Planning)

- Optimal design of transport infrastructure
- Transportation demand forecasting models for passengers and freight (modelling tools for transport demand forecasting)
- Mass Transit Systems (Urban Transit System)
- Development of dynamic information systems and telematics networks - Dynamic map of traffic in Athens
- Contribution in the development of the National intelligent research infrastructure for transport (ENIRISST)

Terminal design and operations

- Simulation of ports, railways, air and water-airports operations
- Innovative handling systems for unitized cargoes

Freight transport in Greece and Europe

- Support in the development of the intermodal transport service in the Athens-Thessaloniki railway route
- Green intermodal freight transport networks in the Balkan area
- Urban freight transport - Freight villages

Laboratory of Railways and Transport

1.3.12 Laboratory of Traffic Engineering

It was established in 1998. The scope of the Laboratory is the planning, design, implementation, operation and exploitation of the urban and interurban road traffic and parking systems. In particular, the Laboratory is active in the following scientific fields:

Traffic Management

- Data driven traffic flow analysis and forecasting
- Traffic and safety of motorcyclists, cyclists and pedestrians
- Mobility optimization, electromobility, shared mobility
- Design and operation of parking systems, on and off road

Traffic Safety

- Driver behaviour and road user safety
- Management of road infrastructure and traffic safety
- Road safety data and information systems

Intelligent Transportation Systems and Automation

- Telematics applications for traffic safety and optimization
- Applications of Cooperative Intelligent Transportation Systems
- Traffic Automation and Connectivity

Laboratory of Traffic Engineering – Driving Simulator

1.3.13 Laboratory of Soil Mechanics

It was established in 1943. The laboratory is equipped with state-of-the-art advanced testing facilities used for the understanding of fundamental behaviour of soils and weak rocks. Research is focused upon:

- The mechanics, behaviour, and strength and deformation properties measured with local instrumentation on soil samples (LVDTs, bender elements etc.).
- The generalized loading conditions (anisotropic) encountered in foundations, earth-retaining and earth-fill structures, underwater slopes, and on seabed surface under the wave action and/or gravity-based foundations.
- The interrelationship between geotechnical and seismic characteristics of sediments, their liquefaction potential and stabilization methods.
- Artificial cementation (using nano-particles, slag, bio-cementation) to improve the mechanical properties of problematic soils.
- Remote monitoring of structure and ground movements.
- Numerical methods, numerical algorithms and constitutive models of soil behaviour under generalized loading conditions.
- Site-specific seismic hazard assessment; analysis and design of soil-foundation-structure interaction systems.

Laboratory of Soil Mechanics

1.3.14 Laboratory of Foundations Engineering

It was established in 1962. Under its auspices it also includes the informal Laboratory of Engineering Geology & Rock Mechanics. These laboratories are active in the following fields:

- Design of geotechnical works under static and dynamic – seismic loading.
- Laboratory assessment of the geotechnical design parameters using conventional but also state-of-the-art soil and rock engineering testing.
- Execution of in-situ geophysical measurements [Crosshole and Downhole seismic testing, ground vibrations measurement (from blasting, heavy traffic, etc.)]
- Environmental geotechnics, with emphasis on the characterization and the remediation of contaminated sites
- Development of new constitutive laws for geomaterials and implementation in advanced numerical solution algorithms (Finite Element and Finite Difference methods)
- Analysis of static and seismic problems of geotechnics with the use of advanced numerical techniques.
- Engineering Geology and Rock Mechanics, with emphasis on the design of Civil Engineering works (rock slopes, dams, tunnels, etc.)

Laboratory of Foundations Engineering

1.3.15 Personal Computer Laboratory

The Personal Computer Laboratory (PC-Lab) supports teaching and research needs of all Sectors of the School of Civil Engineering: Structural, Water Resources and Environment, Transport and Transport Infrastructure, Geotechnical Object of the Laboratory is the research and support in the use of new digital technologies applied in the design, execution, operation and management of technical projects. The technologies in question which specialize in the following areas:

- Building Information Modelling Technology (BIM), for the design (3D BIM), the management (4D & 5D BIM and the operation of the projects (6D & 7D BIM & Digital Twin)
- 3D Capture & Modelling Technology (Reality Capture, Scan to BIM, 3D Laser Scanning, LiDAR, SLAM, Drones)
- Virtual & Augmented Reality Technology (VR / AR)
- Digital construction site connection technology (Smart Construction Connected Site, Machine Control, telematics guidance and real-time construction machinery and site control).
- Artificial Intelligence, Robotics and 3D Printing Technology.

2 Educational Procedures

2.1 General

With the program of studies, the on-campus educational activities are mainly concentrated between the hours of 8:45 - 15:30 (Monday-Friday), offering both students and personnel the requisite time for access to the abundant sources of knowledge available.

The lessons are conducted on the premises of the NTUA Zografou Campus. For the convenience of both personnel and students, signs with both the timetable of the lessons and the teaching staff are posted at easily accessible locations within the building housing the lecture rooms.

The Secretariat of the School is located in the Administration building of the School at the Zografou Campus and is open to the public (students etc.) 11:00 - 13:30 (Monday-Friday). The telephone numbers and emails of the Secretariat, as well as those of the teaching staff, are available on the NTUA website.

2.2 Useful Information

Useful information on the most frequently asked topics:

1. **Admission** of the students to the School for the 1st semester is performed strictly electronically through the platform provided by the Ministry of Education. With the registration to the School, all classes for the 1st semester are automatically declared. If a student does not wish to register for a specific 1st semester course, he/she must inform the School Secretariat.

2. Students receive **codes** from the IT centre (http://www.central.ntua.gr/) at the email address they declare. With these codes the gain access to:

   - **student ID acquisition**: http://academicid.minedu.gov.gr/;
   - **books/notes**: http://eudoxus.gr/;
   - **lesson information and communication with teaching staff:** https://mycourses.ntua.gr/.

3. For any **problems** or **requests** students can contact their **Academic Advisor,** whom they select through an application on the website of the School. Until a student selects an academic advisor, the Student Affairs Committee of the School fulfils that role. The students should first notify the Advisor before forwarding any special request to the School.

4. **Each semester, students are invited** to perform the following, exclusively **electronically**, on dates which are announced on the School's website:

   - **enrolment** for the semester**;**
   - **registration for courses** of the current semester (as well as courses owed from previous semesters, when in a higher semester, with a maximum limit of 10 courses per semester);
   - **request for books/notes** for the courses of the current semester.

5. **For higher semesters** the following extra steps are required:
    - in the **7th semester** the choice of a **concentration of studies (**an informational daily presentation takes place during the 6th semester);
    - in the **9th semester Diploma Theses** are assigned with the prerequisite that the student has less than 10 remaining courses to pass.
6. **Provision of certificates:** by applying to the Secretariat of the School either a) via the School's website, b) via email (admin@civil.ntua.gr), c) via fax (210 772 2294), (d) via a Citizens' Service Centre (ΚΕΠ) or e) with an in-person application at the office of the Secretariat. For standard certificates no application is required, and the certificate is issued forthwith and given to the applicant without delay (same day) after a verbal request.
7. **Usage of the student Dormitories:** provision of a certificate of enrolment from the School and further information at http://www.esties.ntua.gr/.
8. **Examinations:** Students have the right to participate in the examinations only for the courses for which they have registered at the beginning of the semester.
9. **Diploma Thesis Examinations**: For the examination of the Diploma Theses, which takes place on dates set forth in the Academic Calendar (thrice per year) it is a prerequisite that the student has passed all other courses.
10. **Improvement of a grade for a course:** can be requested (with an application after the corresponding announcement from the Secretariat) for courses in which the student has received a passing grade during the regular examination period of the same year. These retesting examinations are carried out in September.
11. **Exemption from a course:** An application is submitted along with the grade and a detailed course description from the *Origin School*. Specifically for the foreign language courses of the 3rd semester, the student may submit a foreign language certificate.
12. **Use of the Library:** upon presentation of a valid student ID. Information at http://www.lib.ntua.gr/.
13. **Possibility of subsidized (gratis) meals**: A certificate can be issued by the Secretariat. Information and the required documents for the meal card can be found at the Office of Student Welfare (Thomadeio building, http://www.ntua.gr/sitisi_oria_eisodimatos.pdf). Subsidized (gratis) meals are provided in the Zografou Campus restaurant, for all students meeting certain income requirements. For the remaining students, the restaurant offers meals at a reduced student price.
14. **Possibility for participation in Student Exchange (ERASMUS)**: Information at the Erasmus office (Administration building, Zografou Campus) or electronically at http://erasmus.ntua.gr/.
15. **Possibility for participation in extracurricular activities:** upon presentation of a valid student ID. Information at the Music Department and the Physical Education Department.
16. **Capability of organizing online courses and exams**: Due to the health requirements that were enforced as a consequence of the COVID-19 pandemic, which took place in the period 2020-2021, the School realised an immediate transition to online educational activities, as needed. Thus, the seamless flow of the educational process was ensured, in compliance with all the health protocols.

2.3 Entry Exams

Graduates of other departments or Schools who wish to enrol in the School in order to obtain a Degree in Civil Engineering, have the opportunity to submit an application from 1st to 15th November of each academic year. The selection process adheres to the current legislation and, each year, it is outlined in an announcement at the School site (http://www.civil.ntua.gr/info/entryexam/) which is posted by the end of April.

3 Curriculum

3.1 General principles

The courses are categorised according to the Department or School of origin, are distinguished in specific types and cover all the scientific areas of interest of Civil Engineering. The first six semesters consist exclusively of core courses, while in the 7th semester the students must select a Concentration of Studies (Structural or Hydraulic or Transportation or Geotechnical Engineering) and follow the corresponding curriculum.

For the categorization of the courses, the following abbreviations are used:

CODE	DEPARTMENT	SCHOOL
ΑΝ	Humanities Social Sciences and Law	Applied Mathematical and Physical Sciences
ΑΡ	(Architecture)	Architecture
ΓΕ	Geotechnical Engineering	Civil Engineering
ΔΟ	Structural Engineering	Civil Engineering
ΜΑ	Mathematics	Applied Mathematical and Physical Sciences
ΜΕ	Transportation Planning and Engineering	Civil Engineering
ΜΗ	Mechanics	Applied Mathematical and Physical Sciences
ΞΕ	Foreign Languages	
ΤΟ	Topography	Rural, Surveying and Geoinformatics Engineering
ΥΔ	Water Resources and Environmental Engineering	Civil Engineering
ΦΥ	Physics	Applied Mathematical and Physical Sciences

CODE	TYPE
Y	Mandatory
E	Elective or interdepartmental group
YK	Mandatory for a Concentration
YK-E	Mandatory for one Concentration and Elective for the rest
EK	Elective for a Concentration

CODE	DOMAIN
AN	Humanities and Languages
AY	Architecture, Building Technology and Materials
ΓΕ	Geotechnics
ΓΠ	Geosciences & Environment
ΔΕ	Project Management
ΔΟ	Structural Engineering
ΜΕ	Transportation Engineering
ΜΥ	Mathematics and Calculus
ΥΔ	Hydraulics and Water Resources
ΦΜ	Physics and Mechanics

The courses of an interdepartmental group coincide regarding their time of conduct (to ensure the feasible implementation of the timetable during the morning hours). The student can select only one course from the group.

The courses of a group are not necessarily all eligible by every student. For instance, only one course may appear for one concentration (in which case it is mandatory), while in another concentration more than one courses appear (thus giving the possibility of selecting one).

The numbering of the groups follows the method described below:

- The first digit of the number of each group corresponds to the semester (if the group appears in more than one semesters, then the lowest semester is used).

- The second digit corresponds to the Concentration of studies, according to the numerical index described above. Interdepartmental groups are characterised as Concentration 0.
- The third digit is an increasing number for the groups of the semester under consideration.

3.2 Courses

From each numbered group, each student must select one course. If for a Concentration of studies a single course appears in a group, then this course is automatically mandatory for the aforesaid Concentration.

Semester: 1

Required

1. General Building Technology & Architectural Drawing
2. Geology for Engineers
3. Mathematical Analysis & Linear Algebra
4. Mechanics of the Rigid Body
5. Ecology and Chemistry for Civil Engineers
6. Group 101 (choice of one is mandatory):
    - Life-cycle analysis of civil engineering structures
    - Introduction to Energy Engineering
    - History of Architecture
    - Descriptive Geometry
    - Computer Aided Design of Civil Engineering Projects

Laboratories (Mandatory - no grading)

- Laboratory on Materials
- Foreign Languages (Selection of one is mandatory): English Language I, French Language I

Semester: 2

Required

1. Differential Equations
2. Multivariable Calculus
3. Mechanics of Deformable Solids
4. Topics on Architecture & Architectural Synthesis
5. Building Materials I
6. Physics

Laboratories (Mandatory - no grading)

- Laboratory on Materials
- Foreign Languages (Selection of one is mandatory): English Language II, French Language II

Semester: 3

Required

1. Strength Of Materials
2. Numerical Analysis
3. Geodesy (surveying)
4. Dynamics of the rigid body
5. Computer-based Solution Methods
6. Environmental Engineering

Laboratories (Mandatory - no grading)

- Laboratory on Constructions - Geotechnics
- Foreign Languages (Selection of one is mandatory): English Language III, French Language III

Semester: 4

Required

1. Soil Mechanics I
2. Fluid Mechanics
3. Construction Site Organization and Safety - Construction Equipment
4. Probability and Statistics
5. Structural Analysis of Statically Determinate Structures
6. Group 401 (choice of one is mandatory):
    - Surveying Engineering Applications
    - Applied Economics
    - Computer Programming

Laboratories (Mandatory - no grading)

- Laboratory on Constructions - Geotechnics
- Foreign Languages (Selection of one is mandatory): English Language IV, French Language IV

Semester: 5

Required

1. Geometric Design of Roads
2. Soil Mechanics II
3. Structural Analysis of Statically Indeterminate Structures
4. Engineering Hydrology
5. Hydraulics and Hydraulic Works
6. Group 501 (choice of one is mandatory):
    - Introduction to Energy Engineering
    - Operations Research & Optimization

- History of Architecture
- Descriptive Geometry
- Computer Aided Design of Civil Engineering Projects

Laboratories (Mandatory - no grading)

- Laboratory on Water Resources and Environment

Semester: 6

Required

1. Foundations
2. Road Construction
3. Matrix Structural Analysis - 1D Finite Elements
4. Reinforced Concrete I
5. Steel Structures I
6. Transportation Systems Planning

Laboratories (Mandatory - no grading)

- Laboratory on Water Resources and Environment

Semester: 7

Required

1. Earthquake Engineering
2. Construction Management
3. Maritime Hydraulics and Harbour Engineering
4. Reinforced Concrete II

Mandatory in Structural Engineering Concentration

5. Dynamics of Structures
6. Computer Lab - Analysis and Design of Structures
7. Steel Structures II (Group 701)

Mandatory in Hydraulic Engineering Concentration

5. Open Channel And River Hydraulics
6. Group 701 (choice of one is mandatory):
   - Engineering Geology
   - Steel Structures II

Mandatory in Transportation Engineering Concentration

5. Traffic Flow
6. Pavements

7. Group 701 (choice of one is mandatory):
    - Engineering Geology
    - Steel Structures II

Mandatory in Geotechnical Engineering Concentration

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5. Dynamics of Structures
6. Experimental Soil Mechanics
7. Group 701 (choice of one is mandatory):
    - Engineering Geology
    - Steel Structures II

Laboratories (Mandatory - no grading)

- Laboratory on Humanities

Semester: 8

Mandatory in Structural Engineering Concentration

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1. Reinforced Concrete III
2. Group 801 (choice of one is mandatory):
    - Renewable Energy and Hydroelectric Projects
    - Quality Control and Quality Assurance
    - Complex Calculus
    - Geographical Information Systems
    - Building materials II
    - Engineering Law
    - Computational Fluid Dynamics
3. Group 802 (choice of one is mandatory):
    - Finite Element Analysis of Structures
    - Structural Reliability and Risk Analysis
    - Light Metal Structures
    - Timber Structures
    - Steel Structures III
    - Engineering Seismology
4. Bridge Design I (Group 803)
5. Nonlinear Structural Analysis (Group 805)
6. Steel-Concrete Composite Structures (Group 806)

Mandatory in Hydraulic Engineering Concentration

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1. Group 801 (choice of one is mandatory):
    - Renewable Energy and Hydroelectric Projects
    - Rock Mechanics - Tunnels

- Quality Control and Quality Assurance
- Complex Calculus
- Geographical Information Systems
- Building materials II
- Engineering Law
- Computational Fluid Dynamics

2. Groundwater (Group 802)
3. Group 803 (choice of one is mandatory):
   - Bridge Design I
   - Flood Risk Management
   - Advanced Geotechnical Works
4. Coastal Engineering (Group 805)
5. Sanitary Engineering (Group 806)
6. Group 824 (choice of one is mandatory):
   - Irrigation Engineering
   - Hydraulic Structures & Dams

Mandatory in Transportation Engineering Concentration

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1. Urban Road Networks
2. Special Topics of Road Geometric Design
3. Railway Engineering
4. Public Transit Planning
5. Group 801 (choice of one is mandatory):
   - Renewable Energy and Hydroelectric Projects
   - Rock Mechanics - Tunnels
   - Quality Control and Quality Assurance
   - Complex Calculus
   - Geographical Information Systems
   - Building materials II
   - Engineering Law
   - Computational Fluid Dynamics
6. Pavement Evaluation and Maintenance (Group 805)

Mandatory in Geotechnical Engineering Concentration

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1. Computational Geotechnics
2. Rock Mechanics - Tunnels (Group 801)
3. Group 802 (choice of one is mandatory):
   - Finite Element Analysis of Structures
   - Structural Reliability and Risk Analysis
   - Light Metal Structures

- Engineering Seismology
- Groundwater

4. Advanced Geotechnical Works (Group 803)
5. Group 805 (choice of one is mandatory):
   - Coastal Engineering
   - Pavement Evaluation and Maintenance
   - Nonlinear Structural Analysis
6. Group 806 (choice of one is mandatory):
   - Steel-Concrete Composite Structures
   - Engineering Law
   - Sanitary Engineering

Laboratories (Mandatory - no grading)

- Laboratory on Humanities

Semester: 9

Mandatory in Structural Engineering Concentration

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1. Group 901 (choice of one is mandatory):
   - Seismic Retrofit and Strengthening of Existing Structures
   - Soil Dynamics
   - Plates & Shells - Special Issues in Finite Element Analysis
   - Mechanics of Masonry
   - Stochastic Methods
   - Composite Materials
2. Group 902 (choice of one is mandatory):
   - Soil-Structure Interaction
   - Advanced Topics in Reinforced Concrete
   - Nonlinear Behaviour of Steel Structures
   - Environmental Impacts
   - Boundary Elements
   - Technology of Building Information Modelling (BIM)
3. Bridge design II (Group 904)
4. Prestressed Concrete (Group 906)
5. Earthquake Engineering II (Group 908)
6. Integrated Project in Structural Engineering

Mandatory in Hydraulic Engineering Concentration

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1. Group 901 (choice of one is mandatory):
   - Seismic Retrofit and Strengthening of Existing Structures
   - Plates & Shells - Special Issues in Finite Element Analysis

- Mechanics of Masonry
- Stochastic Methods
- Composite Materials

2. Group 902 (choice of one is mandatory):
    - Soil-Structure Interaction
    - Advanced Topics in Reinforced Concrete
    - Nonlinear Behaviour of Steel Structures
    - Environmental Impacts
    - Technology of Building Information Modelling (BIM)
3. Group 904 (choice of one is mandatory):
    - Off-shore Structures
    - Environmental Hydraulics
4. Group 923 (choice of one is mandatory):
    - Wastewater Treatment and Disposal Plants
    - Advanced Topics in Port Engineering
5. Group 925 (choice of one is mandatory):
    - Water Resources Management
    - Ecological Models for Surface Water
6. Group 927 (choice of one is mandatory):
    - Integrated Project in Hydraulic Engineering
    - Experimental Hydraulics

Mandatory in Transportation Engineering Concentration

1. Traffic Management and Road Safety
2. Airport Planning and Management
3. Group 901 (choice of one is mandatory):
    - Integrated Project in Transportation Engineering
    - Stochastic Methods
4. Group 902 (choice of one is mandatory):
    - Soil-Structure Interaction
    - Advanced Topics in Reinforced Concrete
    - Nonlinear Behaviour of Steel Structures
    - Environmental Impacts
    - Technology of Building Information Modelling (BIM)
5. Group 906 (choice of one is mandatory):
    - Advanced Topics on Pavements
    - Analysis Methods in Traffic Engineering
    - Quantitative Methods in Transportation
6. Combined Transport - Advanced Systems (Group 908)

Mandatory in Geotechnical Engineering Concentration

1. Selected Topics in Foundation Engineering
2. Soil Dynamics (Group 901)
3. Soil-Structure Interaction (Group 902)
4. Group 904 (choice of one is mandatory):
    - Bridge design II
    - Off-shore Structures
    - Environmental Hydraulics
5. Group 906 (choice of one is mandatory):
    - Advanced Topics on Pavements
    - Environmental Geotechnics
    - Prestressed Concrete
6. Group 908 (choice of one is mandatory):
    - Earthquake Engineering 2
    - Integrated Project in Geotechnical Engineering
    - Combined Transport - Advanced Systems

Internship

10th Semester

Elaboration of Diploma Thesis

3.3 Diploma Thesis

The Diploma Thesis (DT) is an extensive work – analytical, deductive or applied – which is prepared by the senior students at the end of their studies, in order to acquire the Diploma of a Civil Engineer of NTUA. At 5-7-1991 the Senate decided the establishment of general specifications regarding the development of the Diploma Theses of all students of NTUA. The details are determined by the Schools. The remarkable qualities of the DT can be derived through the comparison with the German *Diplomarbeit*, the French *Thèse de diplôme* and the Anglo-Saxon *Thesis of Master of Science or Master of Engineering*, which are practically equivalent.

The entire 10th semester is dedicated to the Diploma Thesis, during which the student need not attend any courses. The application of a student for the assignment of a subject of Diploma Thesis can be filled at the end of the 8th semester, but its development typically starts at the end of the 9th semester.

In particular, the student, during the development of his/her diploma thesis, must work according to the following guidelines:

- Applies or completes various aspects of knowledge of his/her studies, for better assimilation.
- Practices in the search of literature and other sources of information which lead the way towards research.
- Applies the scientific methodology within the framework of a research activity.

It is reminded that each student is responsible for the work taking place for his/her Diploma Thesis and should take valid initiative to that end. As a result, the mere application of the supervisor's instructions, without at least critical review/analysis on behalf of the student, must be avoided.

The Diploma Thesis, depending on its main objective, can be classified as:

- Independent literature synthesis (documentation, description and validated review). Not a simple translation.
- Design of a major technical project in a phase of preliminary or/and detailed design (numerical investigation or/and research contribution, where the procedures are always based on evidence and in accordance with the recognized/taught scientific methods).
- Partially research subject (processing of another's source test results and critical presentation, or/and personal theoretical contribution, or/and personal execution of experiments, or/and composition of original computer source code).

The ideal period for the commencement of the Diploma Thesis, at the chosen scientific field, is the beginning of the 9th semester, so that potential subjects that require significant time to process can be dealt with efficiently. Such subjects can be the acquisition of hard-to-get additional bibliography that needs to be ordered from abroad, the preparation of test specimens and setups, travel to worksites or factories etc.

As a rule, work on the DT can commence, substantially and formally, after filing the corresponding application to the School Secretariat and the determination of the subject.

For every taught course, applications are accepted for the development of a Diploma Thesis. Each student selects two Departments, in order of preference. The School, based on these applications, divides the students in the Departments, based on the capabilities and the courses taught by each Department, the subject of the Thesis, the Concentration of study of the student and his/her corresponding performance.

The definition of the subject is appropriate to take place after the proposal of the student and discussion with the Supervisor of the Diploma Thesis. After the finalisation of the subject, the supervisor must inform the Head of the Department in writing.

Each student must work and submit his/her Diploma Thesis individually. Team theses are allowed for a maximum of two students, provided that such a necessity can be derived by the subject and content of the project, e.g. when besides the theoretical work, substantial laboratory work is required with a significant number of time-consuming measurements, or when extensive use of a personal computer is required. In any case, each student should develop his initiative individually.

It is useful for the student to seek out and start to study the relevant bibliography as soon as possible. Sources for this search can be the notes and books of the courses that are contextual to the Thesis' subject, as well as scientific articles which can be found in Journals.

During the development of the Thesis, the Supervisor that was appointed from the Department is responsible for the monitoring of the progress of the Thesis. One month before the potential date of submission of the Thesis, the Supervisor must inform accordingly the Head of the Department, in writing.

During the development of the Thesis, the Supervisor is observing the student, while simultaneously his scientific initiative is encouraged and reviewed. The final size of the Diploma Thesis depends on the intermediate milestones of the work, while the time needed for completion depends on the satisfaction of the requirements imposed by the subject. Reluctance or failure of the supervisor to effectively supervise the Diploma Thesis is a major academic misconduct.

4 Courses

4.1 1st Semester

English Language I

Course Description

The English language course aims at familiarizing students with language use in a variety of social contexts and communicative tasks (development of linguistic awareness). A range of practical activities involving basic grammatical and syntactic structures are regularly provided along with activities designed to develop understanding and production of relatively simple written language. The level attained at the end of the semester is equivalent to A2, as it is defined by the Common European Framework of Reference for Languages.

Semester: 1

Teaching hours: 2

Life-cycle analysis of civil engineering structures

Course Description

Introduction of the new student into the scientific and professional field of civil engineering: analysis of projects' life cycle; examples of engineering approach to problem solving; regulatory framework; feasibility studies; project financing; administrative permits; contract procurement and management; quality management; safety; operation, maintenance and exploitation of projects; project decommissioning and environment restoration.

Semester: 1

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Built environment and civil engineering projects. Short historical flashback. Life cycle phases. Projects' dimensions: social, financial, environmental, technical, organizational, entrepreneurial. Civil engineering science, studies and profession. Professional ethics, risks and satisfaction.	3
2	Engineering approach	Engineering approach to problem solving. Indicative examples: retaining walls, landslides, irrigation channels etc.	3

3	Legal framework	Introduction to law: public, penal, civil, commercial etc. Regulatory framework of permits: environmental, archaeological, spatial planning, urban planning, energy etc. Public and private contracts.	3
4	Feasibility studies	Project conception. Cost Benefit Analysis. Decision making methods and criteria. Financial, economic and social analysis. Environmental impacts. Cash flow analysis. Construction of a block of flats: construction contract, financing model, risk analysis, apartment sale contract.	6
5	Public works financing programs	Supranational, national and regional planning and scheduling of infrastructure projects. Public investments program. EU co-financing. Public and private partnerships. Public works concessions.	3
6	Public works contracts	Project Owner / Client. Designers. Contractors. Categories and stages of designs. Procurement procedures. Fees. Structure and Content of Tender Documents. Award procedures and criteria. Contract management.	6
7	Public and private works costing	Estimation of works quantities and cost. Contract Budget. Analytical calculation of works' prices. Measurement of works' quantities. Bills and payment orders.	6
8	Quality management	International and national Technical Specifications and Regulatory Framework (European Regulation 305, CE marking etc.). Design instructions. Quality control of materials and works. Quality assurance. Certification and accreditation.	3
9	Safety and Health at work	Basic requirements of OHSAS 18001 International Standard; inspection techniques. National Legislative Framework for Health and Safety at Work; obligatory documentation. Employer and employee responsibilities. The Role of the Safety Engineer.	3
10	Operation, maintenance and exploitation of projects	Legislative framework and theoretical approaches. Case studies: block of flats' operation, motorway company, land irrigation agency. Project decommissioning and environmental landscape restoration.	3

Learning Objectives

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

- recognize the breadth and dynamics of the science and the profession of civil engineer;
- understand the need for a holistic view of each technical project's lifecycle;

- develop the first elements of engineering thinking to address technical problems;
- acquire limited ability to financially analyse a project and organize its documentation.

French Language and Technical Terminology

Course Description

The primary goal of this course is to introduce first year students to basic concepts of French scientific terminology in order to help them correspond to the needs of modern science. Also, the course aims at introducing students to basic morphosyntactic phenomena of the French language through academic texts in order to develop the skills needed for the comprehension and production of academic discourse. The course is supported by the instructor's appropriate teaching material and "My Courses" NTUA platform of asynchronous tele-education.

Semester: 1

Teaching hours: 2

General Building Technology & Architectural Drawing

Course Description

Typesetting, Writing of letters and numbers. Drawing of buildings in plan, sections and sideview. Site plan and coverage plan. Reference to building technology and basic construction materials. Construction of main structure. Drawing of reinforcement plans. Types of internal and external walls. Floors and roofs. Water, thermal and sound insulations. Waterproofing of roofs and basements. Roofs. Types of internal and external doors and windows. Scales. Specific subjects of building technology.

Semester: 1

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Use of drawing equipment, types of lines. Exercise	1×3=3
2	General principles of drawing	Drawing of buildings in plan, sections, views, scales, dimensions, levels. Letters, boards, notes. Exercise	1×3=3
3	Introduction to building technology 1	Objectives of building technology. Requirements and performances of building structures. Exercise.	1×3=3

#	Title	Description	Hours
4	Introduction to building technology 2	Construction drawings and design. Project	1×3=3
5	Preliminary on-site works– excavations – foundations	Demolitions, layout design, setup of the surface. General excavations, specific excavations, Excavation plan. Foundation types, strap beams etc. Exercise of a foundation plan.	1×3=3
6	Main structure	Concrete structural elements. Beam and plate elements. Structural types. Types of support. Terminology. Exercise of construction drawing in concrete. Structural elements of steel, timber etc.	1×3=3
7	Vertical lines	Types of stairways and design. Elevators, Exercise of a stairway drawing	1×3=3
8	Partitions	External building envelope, walls, panels, openings. Exercise	1×3=3
9	Roofs	Roofs. Cold and warm roofs. Inclined roofs. Drainage of roofs. Exercise	1×3=3
10	Physical protection	Waterproofing, thermal insulations, water vapor insulation, sound insulation, fire protection. Exercise	1×3=3
11	Finishes	Shaping of final surfaces. Construction details. Exercise	1×3=3
12	Pathology of structures	Analysis of causes (excluding seismic) resulting in damages in buildings, examples of damages, recommendations for prevention of damages. Exercise	1×3=3
13	Pre-fabrication	Dimensional standardization. Tolerances. Main prefabrication technologies. Examples. Exercise	1×3=3

Learning Objectives

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

- know to draw a complete building;
- know the basic techniques needed for its construction;
- form basic architectural spaces in connection with the dimensions of the structural elements;
- integrate the basic principles of other specialties (thermal, sound insulation etc.) into building planning.

Geology for Engineers

Course Description

Application of Geology to Engineering. Earth materials. Description and properties of the main rock forming minerals and rocks. Mechanical behaviour of rocks in engineering works. Internal and external geological processes. Weathering and erosion. Geomorphology. The role of underground water. Landslides; subsidence; earthquakes. Geological maps and related geological data for studies and construction of engineering works.

Semester: 1

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction-Applications of Geology	Main subjects of Geology. Application of Geology in Engineering. Geology and engineering works. Case histories in Greece and other countries.	12
2	Geological processes	Internal and external geological processes. Weathering and erosion. Geomorphological processes. The cycle of water. Underground water and engineering works. Geological maps and related geological data for studies and construction of engineering works.	12
3	Geo-materials	The earth structure and geo-materials. Description and properties of the main rock forming minerals. Soil, rock and rockmass. Soil formations and their behaviour in engineering works. Igneous, metamorphic and sedimentary rocks: properties and engineering behaviour. Case histories.	16
4	Geological catastrophic phenomena	Landslides (description, classification, recognition and mitigation; their effect on engineering works). Earthquakes (genesis, terms, fault characteristics and classification; active tectonics; seismic risk and secondary phenomena). Volcanism. Emphasis on the seismicity of Greece. Case histories.	12

Learning Objectives

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

- know the geological structure and geo-materials (soils and rocks) of Earth crust where the engineering works are constructed;
- know the basic principles of geological mapping.

Introduction to Energy Engineering

Course Description

Introduction to energy and electrical energy. Production, transfer, demand of electrical energy. Wind energy. Solar energy. Hydroelectric energy. General components of hydroelectric works (power stations, water intakes, dams). Energy storage using pump-storage systems. Fossil fuels (petroleum, natural gas, coal, nuclear). Thermal stations. Biomass (Biofuels-Biogas). Geothermic energy. Marine energy (waves, tides, currents). Energy economics. Energy mix.

Semester: 1

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduction to energy. Types of energy, physical quantities and units. Introduction to electrical energy. Production-demand-transfer of electrical energy. Energy mix.	6
2	Wind energy	Theoretical and technically exploitable wind potential. Wind turbines (installation, environmental impacts).	3
3	Solar energy	Solar radiation (spatial-temporal distribution). Electric solar energy systems. Photovoltaic panels	3
4	Hydroelectric energy	Evaluation of hydro-potential. Characteristics of hydroelectric energy works. Evaluation of small hydropower plants.	3
5	Hydroelectric energy	General layout (power stations, water intakes, dams, penstocks, turbines). Hydroelectric power station operation. Pump-storage systems.	3
6	Fossil fuels	Fossil fuels characteristics (Petroleum, natural gas, coal, nuclear). Fossil fuels energy assessment. Assessment of environmental impacts and greenhouse gas emissions.	3
7	Thermal stations	Layouts of thermal stations. Production of fossil fuels. Procedures for electrical energy production.	3
8	Energy works	Presentation of energy works from the students	3
9	Marine energy	Energy from waves, tides and currents. Assessment of marine energy potential. Layouts of electrical energy production.	3

10	Biomass. Geothermic energy	Electrical energy from biomass-biofuels. Energy from solid and liquid waste. Geothermal fields. Geothermic power plants.	3
11	Financial issues of energy	Energy economics. Electrical energy market.	3
12	Lesson review	Course review. Example of energy mix development	3

Learning Objectives

- Familiarization with fundamental energy physical quantities (power, energy, capacity factor)
- Evaluation of wind, solar and hydroelectric potential
- Evaluation of: energy production from fossil fuels, produced pollutants and greenhouse gasses.
- Understanding the basic financial measures of energy projects and the energy market framework
- Introduction to energy projects design related to civil engineering (hydroelectric power, wind power and solar power projects)

Laboratory on Materials

Course Description

Laboratory exercises for aggregates, concrete, metals, wood, soil, composites, asphalt constituents and materials, natural stones and artificial bricks. Metrology and measurement techniques.

Semester: 1

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Safety and Health	Marking and instructions. Precautions and means of personal protection. First Aid.	1×3=3
2	Measurement devices and methods	Metrology and measurement techniques. Loading and deformation measurement and devices. Calculating and statistical analysis.	
3	Aggregates	Grain size analysis, sand density, absorption of coarse aggregates	1×3=3
4	Concrete	Concrete mix design, study on concrete’s properties, at fresh (slump, density, entrained air) and hardened (concrete strength) state, calculation of compressive strength.	1×3=3

#	Title	Description	Hours
5	Soil	Students are introduced to the particulate nature of soil by handling sand and silt particles and dried out clay minerals. Natural soils are also examined and the methods used to define their grading are discussed. The soils' ability to resist loads is examined with the aid of simple model tests on disks simulating soil grains. The effect of gravity and water in soil strength is acknowledged through simple experiments, indicating that soil is a very complex material. The students are introduced to soil classification tests by handling a natural clay at its liquid and plastic limit state, and by measuring the density of a sand.	3×3=9
6	Steel	Ductile fracture. Stress / strain draft diagram. Determination of yield strength and material characterization based on yield strength. Calculation of Modulus of Elasticity. Calculation of strains (plastic, total).	1×3=3
7	Aluminium	Brittle fracture. Stress / strain draft diagram. Calculation of yield strength. Determination of ultimate strength and materials characterization. Calculation of Modulus of Elasticity	1×3=3
8	Clay Masonry Units	Methods of testing for clay masonry units. Determination of dimensions, determination of flatness, determination of compressive strength (mean value and standard deviation).	1×3=3
9	Asphalt – Asphalt mix	Determination of asphalt softness or hardness and its role in asphalt mix performance. Viscoelastic behaviour of asphalt mix	1×3=3

Learning Objectives

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

- recognize structural characteristics and properties of the materials;
- measure physical and mechanical quantities related to the materials' properties;
- calculate and characterize civil engineering materials according to their properties;
- recognize the mechanical behaviour of the civil engineering materials.

History of Architecture

Course Description

Becoming familiar with Architecture and building techniques from ancient to modern times, in the Greek and international environment. Relationships of forms, rhythms and construction methods. Relationships of forms and functionalities in historical buildings. Modern Architecture in Greece and internationally.

Semester: 1

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduction to the history of Architecture, issues of historiography, rhythms, architectural typologies and forms.	1×2=2
2	Minoan-Cycladic-Mycenean Period	Issues of typological analysis, issues of architectural forms, reference to the use of the structural system "beam on column", understanding of its construction role.	2×3=6
3	Roman period – Byzantium – Middle ages	Issues of typological analysis, issues of architectural forms, reference to the use of arched systems, understanding of its construction role.	2×3=6
4	15th-18th century	Issues of typological analysis, issues of architectural forms, reference to the use of mixed structural systems, differentiation of the role for their structural members.	2×3=6
5	19th-20th century	Issues of typological analysis, issues of architectural forms, reference to reinforced concrete, steel, composite, or timber structures, differentiation of the role of these systems.	2×4=8
6	20th-21st century	Issues of typological analysis, issues of architectural forms, reference to innovative reinforced concrete, steel and composite structures, differentiation of the role of these systems.	2×4=8
7	Synopsis - Epilogue	Comparative notes and conclusive remarks on structures, both in respect to Architecture, as well as in respect to the development of the structural systems, their application in various periods and their influence in the structural forms and typologies.	1×3=3

Mathematical Analysis & Linear Algebra

Course Description

Mathematical Analysis: Real numbers (topology of R, supremum and infimum of a set, the Bolzano-Weierstrass theorem). Sequences of real numbers, convergence tests. Series of real numbers, convergence tests. Calculus of functions of one variable, fundamental theorems, Taylor-McLaurin formula, extremals. Power series (Taylor – Mac-Laurin). The indefinite integral, methods of integration. The Riemann integral (definition, tests of integrability, applications). Improper integrals of first and second type, calculation and convergence tests. The integral test for convergence of series.

Linear Algebra: The complex numbers. Vector calculus, the equations of line and plane in 3-space and applications. The sphere, cylindric and conic surfaces. Surfaces of 2nd degree, projection of a space curve on the coordinate planes. Matrices, determinants, rank of a matrix. Linear systems of equations, Gauss elimination method, the method of Cramer, invertible matrices. Vector spaces and subspaces. Linear span, linear dependence-independence, basis of a vector space, change of basis matrix. Linear functions (definition, kernel, image, matrix). Linear transformations, examples. Eigenvalues and eigenvectors of linear transformations and matrices (characteristic polynomial, Cayley-Hamilton theorem, matrix diagonalization). Orthogonal and symmetric matrices. Quadratic forms and applications.

Semester: 1

Teaching hours: 6

Course Units

#	Title	Description	Hours
1	Real numbers, Sequences, Convergence,	Real numbers, Topology of R, supremum and infimum, Bozano-Weierstrass theorem, Sequences of real numbers, convergence tests.	2×3=6
2	Series, Convergence tests.	Series of real numbers, convergence, absolute convergence, Series with nonnegative terms, Alternating series, convergence tests.	3×3=9
3	Differential Calculus	Differential calculus of one variable, fundamental theorems, Taylor- Maclaurin formula, Exremals, Power series (Taylor – Mac-Laurin).	2×3=6
4	Integral Calculus	Indefinite integral, methods of integration. The Riemann integral (definition, tests of integrability, applications).	4×3=12
5	Improper Integrals	Improper integrals of first and second type, calculation and convergence tests. The integral test for convergence of series.	2×3=6
6	Complex numbers, Vector Calculus	The complex numbers. Introduction to vectors, vector products.	2×3=6
7	The Line in space, the Plane, Surfaces	The line in 3-space and applications. The plane and applications. The sphere, cylindric and conic surfaces. Surfaces of 2nd degree, projection of a space curve on the coordinate planes.	3×3=9
8	Matrices, determinants, linear systems	Introduction to matrices. Determinants, rank of a matrix. Linear systems, Gauss elimination method, the method of Cramer, application to inversion of matrices.	3×2=6
9	Vector spaces, Basis, Dimension	Vector spaces and subspaces. Linear span, linear dependence-independence, basis of a vector space, change of basis matrix.	2×3=6

10	Linear Functions	Linear functions (definition, kernel, image, matrix). Linear transformations, examples.	3×2=6
11	Eigenvalues and Eigenvectors, Quadratic Forms	Eigenvalues and eigenvectors of linear transformations and matrices (characteristic polynomial, Cayley-Hamilton theorem, matrix diagonalization). Orthogonal and symmetric matrices. Quadratic forms and applications	3×2=6

Learning Objectives

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

- basic concepts and results of the differential and integral calculus of functions of a variable;
- basic concepts and results of Linear Algebra and Vector Analysis.

Mechanics of the Rigid Body

Course Description

Principles of mechanics and their application for solving problems regarding loaded bodies in two and three dimensions.

Semester: 1

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Basic concepts.		4
2	Elements of Vector Calculus.		4
3	Systems of forces and moments in two and three dimensions.		4
4	Equations of static equilibrium.		4
5	Types of loads. Basic structural systems.		4
6	Supports, reactions, plane statically determinate systems.		4
7	Plane statically determinate trusses.		4
8	Plane statically determinate trusses.		4
9	Beams (internal forces).		4
10	Statically determinate frames (internal forces).		4
11	Area moments of inertia. Centroid. Flexible cables. Catenary.		4

#	Title	Description	Hours
12	Work and energy. Principle of virtual work.		4
13	Potential energy and stability. Friction and applications.		4

Learning Objectives

With the successful completion of the course, the students will have obtained a solid background with respect to the fundamentals of mechanics of non-deformable bodies and will be able to successfully attend the following scheduled courses, which are the mechanics of the deformable bodies and the strength of the materials.

Ecology and Chemistry for Civil Engineers

Course Description

Introduction to the principles of ecology, organization of terrestrial and aquatic ecosystems (energy flow, biogeochemical cycling of elements), metabolism of organisms (energetics of organisms under different redox conditions), population interactions, trophic levels. Introduction to inorganic and aquatic chemistry, physicochemical properties of water, methods of expressing concentration of chemical compounds in water. Stoichiometry of chemical reactions, acid base reactions, oxidation reduction reactions. Buffering capacity of water, carbonate system, solubility of solids and gases in water. Chemistry of materials: principles, electronic structure, chemistry bonding, chemical structures of crystals, X ray crystallography, chemical reactions. Soil chemistry: introduction to soil chemistry, physico-chemical properties of soils, physico-chemical processes in soils and water, with emphasis on ionic equilibria, organic complexation, mineral stability, and surface sorption. Introduction to atmospheric chemistry. Human impact on the environment. Natural environment, deforestation, soil pollution, environmental impact assessment. Water pollution, oxygen depletion, eutrophication chemicals pollution. Atmospheric pollution. Introduction to pollution control technology.

Semester: 1

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Ecosystems and organisms	Introduction to ecology, metabolism of organisms, energy production, phytosynthesis, respiration, structure of organisms in communities, ecosystems, terrestrial and aquatic ecosystems	2×3=6
2	biogeochemical cycling of elements, structure of ecosystems	Carbon and oxygen cycle, nitrogen cycle, phosphorus cycle and cycling of other elements, structure of ecosystems, trophic levels, populations interactions, energy flow in ecosystems, limiting factors in ecosystems	1×3=3

3	Principles of inorganic chemistry	Introduction to inorganic chemistry, type of bonds, methods of expressing concentration of chemical compounds in water. Stoichiometry of chemical reactions, acid base reactions, oxidation reduction reactions.	2×3=6
4	Aquatic chemistry	Introduction to aquatic chemistry, physicochemical properties of water, methods of expressing concentration of chemical compounds in water, water hardness, buffering capacity of water, alkalinity, carbonate system, solubility of solids and gases in water.	2×3=6
5	Chemistry of materials	principles, electronic structure, chemistry bonding, chemical structures of crystals, X ray crystallography, chemical reactions.	2×3=6
6	Soil chemistry	introduction to soil chemistry, physico-chemical properties of soils, physico-chemical processes in soils and water, with emphasis on ionic equilibria, organic complexation, mineral stability, and surface sorption.	1×3=3
7	Atmospheric chemistry	Introduction to atmospheric chemistry, primary and secondary air pollutants, photochemical smog, acid rain, ozone pollution, pollution control strategies	1×3=3
8	Human impact on the environment	Natural environment, deforestation, soil pollution, environmental impact assessment. Water pollution, oxygen depletion, eutrophication chemicals pollution. Atmospheric pollution. Introduction to pollution control technology.	2×3=6

Learning Objectives

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

- identify the basic functions in an ecosystem and understand the interactions, both biotic and abiotic, that regulate ecological population size and community structure;
- understand the basic functions of organisms and how organisms influence the flow of energy and cycling of nutrients within ecosystems;
- evaluate human interactions with nature and effects on natural systems;
- understand the behaviour of inorganic species, such as carbonate and trace metals, in water;
- understand acid-base reactions, complexation, precipitation-dissolution, and reduction-oxidation reactions;
- describe the constitution of substances, together with their chemical and physico-chemical properties;
- relate the chemical properties and physico-chemical behaviour of substances with emphasis on X-ray diffraction to their structure and composition.

Descriptive Geometry

Course Description

Learning of descriptive methods (two-dimensional representations of three-dimensional objects constructed following mathematical rules), geometric knowledge enrichment, deepening of the geometrical perception, sharpening of the mathematical thought and especially of the geometrical thought, graphical solutions of technical problems, facilitation of the understanding of computer-generated technical drawings.

Semester: 1

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Stereometry	Basic notions: points, lines, planes, angles (dihedral, trihedral, polyhedral) and their measurement, perpendicularity, parallelism, skew lines, projections (perpendicular, lateral, central), distances, slopes, areas, volumes, the three- perpendiculars Theorem, Thales's Theorem, prisms, pyramids, cylinders, cones, spheres, basic propositions.	3×3=9
2	Descriptive Geometry in two planes	Relative positions of points, lines and planes, inclinations and declinations, true lengths, trace lines, measures, developments. Technical applications: plane intersections of solids, solid intersections, cylindrical helices-turning stairs.	5×3=15
3	Descriptive Geometry in one plane via altitudes	Slopes, steps, trace lines, relative positions of points, lines and planes, measurements, unwrappings. Technical applications: roofs, topographic maps, tunnels, cuts and fills of technical works (bankings).	

Learning Objectives

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

- realize the exceptionally important position of geometry in the knowledge asset of their profession;
- think geometrically, and to cover with only a minimal amount of effort any gaps in their geometric knowledge from their secondary or higher education;
- understand that all technical drawings follow mathematical rules;
- represent three-dimensional objects via two-dimensional drawings (in more than one way);
- solve via graphical but mathematical methods those space problems regarding measurement and incidence in technical drawings;
- work mathematically in certain technical applications.

Computer Aided Design of Civil Engineering Projects

Course Description

Computer Aided Design (CAD) of architectural, structural, hydraulic, transportation and other engineering projects. Elements - linear segments, polylines, circles, etc. Element attributes, layer, colour etc. Editing - erase, copy, rotate, etc. Drafting aids - object snap, grid, rays. Subdrawings - blocks, references. Plotting drawings. Spreadsheets (Excel), application to CAD (clothoid, catenary curves etc). Introduction to the Regulation of the Energy Performance of Buildings (KENAK) - computation using spreadsheets. 3D CAD using solid objects.

Semester: 1

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction to CAD	Introduction to Computer aided design (CAD). CAD software, 1st and 2nd generation. AutoCAD. Presentation of the computer terminals and login practice.	3×1=3
2	AutoCAD statements, coordinates	Introduction to AutoCAD statements - using keyboard, menus or icons. Creating new drawings - acadiso template. Line. Cartesian, relative Cartesian, polar, relative polar coordinates. Exercise: drawing rectangles with absolute and relative coordinates.	3×1=3
3	Elements, editing 1	ARC (centre/radius/angles, 2points/radius, 3points). TEXT (single/multi), text style, effects. POINT, point style. Save files named as draw01, draw02, draw03 (multiple copies so that we can revert to earlier versions). New - acadiso. Copy/paste/paste to original coordinates. Editing statements. ERASE, UNDO/REDO, add, remove and combinations. MOVE, COPY, ROTATE, SCALE.	3×1=3
4	Editing 2, object snap points, inquire statements	2nd editing statements. Statements break, trim, extend. Statements fillet (with intersecting and non-intersecting lines), chamfer, offset (differentiation between line/polyline). Statement array (rectangular). Mirror, lengthen (4 options), stretch, stretch with handles. Description of object snap points, end, mid, cen etc. List statement. Element selection and properties with right click. Statements dist, area. Units statement.	3×1=3
5	Three-dimensional CAD with solid objects	Three dimensions. Axes. Box, cylinder, cone, wedge, torus. Views: top, front, side view. Isometric views. Shading. Editing statements move, copy, erase, scale, rotate in 3-dimensional elements. The object snap points in 3-dimensional elements. Example of 3D design of a temple. Using colours to achieve better optical result.	3×1=3

6	Union, subtraction, intersection of solid objects	3D editing statements. Union, subtract, intersect. Rotate3d, Mirror3d, Array3d, slice. Example of staircase (wedge, box, union). Example of wall opening (box, subtract, box with greater thickness).	3×1=3
7	Solid object creation from cross sections	Solids created by extruding cross sections (plane closed lines). Variable cross section along the z-axis (similarity transformation). Solids of constant cross section along curved axis. Extrude with non-zero angle with respect to vertical axis, positive and negative. Example with extrusion of Pi shaped cross section: curved bridge.	3×1=3
8	Solid object creation from revolving cross sections	Solids created by revolving cross sections. Rectangle to cylinder. Closed polylines to flywheel. Revolving axis outside a polyline to a ring. Narrow closed polyline to shell. Shell fragments with revolving angle < 360 degrees. Example with 90 degrees pipe, and detailed union of pipes.	3×1=3
9	Photo-realism	Shading. Photo-realism. Surface textures. Material library. Editing and creating new textures. Covering solids with textures.	3×1=3
10	Spreadsheets, scripts	Spreadsheets - descriptions, operations, smart copy. Formatting. Example with computation of catenary and clothoid curves. Execution of AutoCAD statements via scripts. Drawing circles, lines (pline with a blank row at the end). Script creation from spreadsheets. Example with drawing of catenary and clothoid curves.	3×1=3
11	Introduction to KENAK	Introduction to the Regulation of the Energy Performance of Buildings (KENAK). Concept of thermal transmittance. Thermal insulating materials. Maximal admissible thermal transmittance per climatic zone. Calculation of weighted average thermal transmittance of a building, and calculation of the maximal admission average transmittance. Examples. Computations using spreadsheets.	
12	Coefficient of thermal conductivity	Coefficient of thermal conductivity / thermal resistance. Thermal conductivity/resistance of materials. Calculation of equivalent thermal transmittance of multi-layer element. Calculation of the necessary thickness of an insulating element. Equivalent thermal resistance of boundary layers, gaps and roofs. Examples using spreadsheets.	3×1=3
13	Thermal bridges	Heat loss due to linear and point thermal bridges. Linear thermal transmittance. Effect on the weighted average thermal transmittance of a building. Horizontal, vertical thermal bridges and thermal bridges of openings. Full example using spreadsheets and AutoCAD. Use of specialized software. Calculation of equivalent thermal transmittance of openings. Example using spreadsheets.	3×1=3

Learning Objectives

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

- create drawings of civil engineering projects;
- realize the value of computers to civil engineering;
- understand each technical project in its entirety;
- structure 3d models of civil engineering projects;
- compute the thermal performance of buildings according to KENAK.

4.2 2nd Semester

English Language II

Course Description

The English language course aims at familiarizing students with language use in a variety of social contexts and communicative tasks (development of linguistic awareness). A range of practical activities in different grammatical and syntactic structures are regularly provided along with activities designed to develop understanding and production of both spoken and written language. The level attained at the end of the semester is equivalent to B1-B2, as it is defined by the Common European Framework of Reference for Languages.

Semester: 2

Teaching hours: 2

French Language II

Course Description

The course aims at examining main morphosyntactic phenomena of the French Language that play a significant role in the process of communication. Specifically, academic texts are used in order to familiarize students with understanding and summary techniques while enriching their vocabulary with basic French scientific terminology. The instructor's relevant didactic material contains authentic sources with parallel use of digital tools. The course is supported by the instructor's appropriate teaching material and "My Courses" NTUA platform of asynchronous tele-education.

Semester: 2

Teaching hours: 2

Differential Equations

Course Description

Study of differential equations. Qualitative theory and basic methods of solving differential equations and systems. Applications to modelling physical problems.

Semester: 2

Teaching hours: 5

Course Units

#	Title	Description	Hours
1	Introduction	Derivation - mathematical models, concept of a differential equation, classification, concept of solution, initial boundary value problems, well-posed problems	2
2	First-order Differential Equations	Linear equations of separated variables, exact differential equation and integrating factors, homogeneous, formulation of the theory of existence and uniqueness, modelling of physical problems.	8
3	Linear Differential Equations	Theory of homogeneous differential equation, linear independence of functions or solutions and Wronskian determinant, Abel's theorem, reduction of the order - d'Alembert's method, non-homogeneous differential equation and the method of varying coefficients - Lagrange method, equations with constant coefficients, characteristic polynomial-simple, multiple, complex roots, method of determining coefficients.	8
4	Laplace Transform	Definition, solving initial value problems, Heaviside and Dirac functions, equations with discontinuous non-homogeneous term, convolution theorem, Volterra equations	6
5	First Order Systems Differential Equation	Homogeneous linear with constant coefficients, complex, multiple eigenvalues, phase portrait, autonomous systems and stability, non-homogeneous linear systems	6
6	Solving Linear Second Order using Power Series	Solution in a regular point, Legendre equation, Legendre polynomials, Euler equation, solutions near a regular singular point, Bessel equation	6
7	Trigonometric Fourier Series	Fourier-Euler coefficients, convergence theorem, even and odd functions -cos and sin expansions, complex form of Fourier series	4

8	Boundary Value Problems	Homogeneous Sturm-Liouville problems, eigenvalues and eigenfunctions	4
9	Separation of Variables	Wave equation-vibrations of an elastic string, D'Alebert's solution. The method of separation of variables in two and three dimensions. Modelling of physical problems	8

Learning Objectives

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

- know the important role of differential equations;
- to have the ability to model using ordinary and partial differential equations;
- understand the importance of analytical and theoretical methods of problem solving.

Multivariable Calculus

Course Description

The Euclidean space Rn. Functions between Euclidean spaces, limit and continuity of functions. Differentiation of vector-valued functions of one variable, applications in mechanics and differential geometry, polar, cylindrical and spherical coordinates. Differentiable functions, partial and directional derivative, the concept of differential. Vector fields, gradient-divergence-curl. Fundamental theorems of differentiable functions: differentiability of composite functions, mean value theorem, Taylor’s formula, implicit function theorems, functional dependence. Local and conditional extremes, Lagrange multipliers. Double and triple integrals: definitions, integrability criteria, properties, change of variables, applications. Contour integrals: Contour integral of the first and second kind, contour integrals independent of path, Green’s Theorem. Elements of surface theory. Surface integrals of the first and second kind. Fundamental theorems of vector analysis (Stokes and Gauss Theorems), applications.

Semester: 2

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	The Euclidean space Rn. Functions between Euclidean spaces, limit and continuity of functions.	3
2	Vector-Valued functions	Differentiation of vector-valued functions of one variable, applications in mechanics and differential geometry, polar, cylindrical and spherical coordinates cylindrical and spherical coordinates.	6

3	Differentiability of functions of several variables.	Differentiable functions, partial and directional derivative, the concept of differential. Vector fields, gradient-divergence-curl. Fundamental theorems of differentiable functions: differentiability of composite functions, mean value theorem, Taylor's formula, implicit function theorems, functional dependence.	6
4	Extremals	Local and conditional extremes, Lagrange multipliers	3
5	Double and triple integrals	Double and triple integrals: definitions, integrability criteria, properties, change of variables.	6
6	Contour integrals	Contour integrals: Contour integral of the first and second kind, contour integrals independent of path, Green's Theorem.	6
7	Surface integrals	Elements of surface theory. Surface integrals of the first and second kind. Fundamental theorems of vector analysis (Stokes and Gauss Theorems), applications.	9

Learning Objectives

Rigorous Analysis on the differential and integral calculus of real functions of several variables.

Mechanics of Deformable Solids

Course Description

Introduction to the Mechanics of Deformable Bodies. Stress and Strain tensors. Constitutive relations of isotropic materials. Elastic constants. Equilibrium, kinematics, compatibility. Linear Elastic analysis of Beams. Technical theories of linear elasticity to analyse flexural, shear and combined loading problems.

Semester: 2

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Definition of stress. Stress vector. Stress tensor.		3
2	Stresses on inclined planes during axial loading of an elastic beam.		3
3	Strains. Axial deformations. Thermal strains		3
4	Constitutive relations of isotropic materials in 1D. Hook's Law Poisson Ratio		3
5	Axial loading of elastic and elastoplastic beams. Loading-unloading. Permanent stresses and strains.		3
6	Shear stress and shear strain. Shear Modulus. Strain tensor. Bulk Modulus. Generalized Hook's Law.		3

#	Title	Description	Hours
7	Stress Transformation. Plane stress. Normal and shear stresses. Principle Stresses and directions. Mohr Circle. Equations of Equilibrium.		3
8	Strains, rotations, Strain Transformation. Principle Strains. Strain rosettes. Compatibility Equations		3
9	Torsion of cylindrical beams (circular cross sections) Elastic and Elastoplastic behaviour (Loading- unloading).		3
10	Pure Bending of elastic beams with symmetric cross section. Stresses, strains, curvature. Moments of Inertia of cross sections.		3
11	Pure Bending of beams with symmetric cross section from elastoplastic material (loading-unloading)		3
12	Shear Stresses in Beams (Shear Stresses due to Bending). Shear Flow, Beams under Combined Axial, Bending, Torsional Loading		3
13	Deflections of Beams. Analysis of simple indeterminate structures		3

Learning Objectives

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

- calculate the stress state (normal and shear stresses) at every point within a symmetric cross section of a structural member when under axial and/or bending and/or shear and/or torsion loads;
- estimate principle stresses and max shear stress as well as the planes they appear;
- calculate the deflection shape/line in simple beam structures due to flexural loading, and invoke compatibility conditions to analyse simple indeterminate structures.

Topics on Architecture & Architectural Synthesis

Course Description

Design of buildings. Introduction to Architecture. Man scale, analysis of activities and equipment of spaces. Ergonomic design in Architecture. Bioclimatic factors influencing architectural design. Selection of construction materials. Selection and description of the main structure. Relation between the function and the form of the building. Elements for organization and compilation of the architectural design.

Semester: 2

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduction to Architecture. Dimensions of fixed and movable furniture. Description and analysis of the project.	3

2	Elaboration of spaces	Processing of furniture and equipment. Creation of spaces. Exercise with determination of minimum dimensions of basic spaces. Correction of project.	3
3	Building program – relation between spaces	Creation of the building program, relation between spaces, distribution over the height, abstract organization charts. Sketch of the Architectural solution. Correction of project.	3
4	Edition of preliminary design	Specifications of spaces dimensions, standardization, layout. Preliminary design: plan, side views, sections. Correction of project.	3
5	Application of specifications	Building specifications, building regulation, passive fire protection. Correction of project.	3
6	Planning of the main structure	Layout of the structural elements – slabs, beams, columns, foundations. Reinforcement drawings. Correction of project.	3
7	Building morphology	Voids and full. Creation of the building facades. Correction of project.	3
8	History of Architecture	Historical development of Architecture. The importance of the modern movement. Architecture and Engineers. Correction of project.	3
9	Bioclimatic design 1	Presentation of bioclimatic design techniques for the design of buildings. Correction of project.	3
10	Bioclimatic design 2	Presentation of bioclimatic design techniques for the design of buildings. Correction of project.	3
11	Main design	Design specifications. Main design. Topographic layout. Final drawings in plan, side views, cross sections (1/50). Correction of project.	3
12	Other designs	Technical description, cost design, architectural construction details. Correction of project.	3
13	Presentation of architectural works	Applications – architectural examples. Correction of project.	3

Learning Objectives

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

- to design a building;
- to plan and design buildings from concrete and other construction materials;
- to execute a complete architectural design;
- to check beams, slabs, columns based on architectural drawings.

Building Materials I

Course Description

Introduction to: materials structure and properties, standardization, designation and specifications. Inspection, testing and measurement techniques. Properties, characteristics and mechanical behaviour of: Natural stones, Binders and Cement, Concrete, Aggregates, Metals and Ceramics, Wood and Polymers. Introduction to erosion and durability. Materials response to thermal and moisture changes and to fire.

Semester: 2

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Evolution on the building materials. Structure. Physical, thermal, mechanical and other properties. Testing, measurement techniques. Standardization and specification of materials.	4
2	Natural stones and their products - Aggregates	Natural stones. Marbles. Deterioration causes, precaution measurements and preservation. Fracture of rocks Aggregates: Origin. Types of aggregates. Production. Mining. Treatment. Classification. Characteristic properties. Conformity. Grading - Fineness modulus. Specified size limits. Testing. Blending of aggregates.	6
3	Cement	Production. Setting and hardening. Standards. Specifications. Standards. Special cements.	4
4	Concrete	Ingredients, structure, strength, deformation, durability, mix design, fresh concrete.	8
5	Building limes - Mortars	Building limes: Production. Setting and hardening. Standards. Clay. Lime. Gypsum. Mortars: Classification. Synthesis. Properties - characteristics. Conformation criteria. Testing. Specifications. Standards. Traditional mortars.	4
6	Ceramics	Production. Shape, natural, mechanical and other characteristics	4
7	Masonry buildings under seismic actions	Types, roles of mortar and masonry units, mechanical characteristics, design parameters, loading capacity, thermal behaviour	4
8	Wood	Wood and wood products. Mechanical properties. Creep - effect of humidity. Durability. Fire protection measures.	4
9	Metals	Structural steel, concrete steel bars: Production, structure, nomenclature, physical and mechanical properties, corrosion and	6

		behaviour in temperature changes. Aluminium, stainless steels (structural applications): Preparation, structure, nomenclature, physical and mechanical properties, behaviour in temperature changes.	
10	Structural and reinforcement polymers	Resins and fibre-reinforced polymers, cellular polymers. Properties, Environmental effects, thermal behaviour and waterproofing.	4

Learning Objectives

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

- recognize structural characteristics and properties of the materials, in order to understand the relation between structure – material properties;
- understand the application of the standardization system to materials technology;
- know key issues of production and technology of all Civil Engineering materials;
- understand the properties and behaviour of all civil engineering materials.

Physics

Course Description

The waves and their propagation properties in elastic media of 1-, 2-, and 3-dimensions, as well as their standing forms in definite size media, are studied, on the base of the wave equation and the proper boundary conditions. Examples of waves in elastic string, of surface waves, of acoustic and electromagnetic waves are given, concluding with the optics laws. After an introduction to the principles of quantum mechanics and the Schroedinger equation, examples of bound quantum systems and discrete energy spectrum are given and the basic operational principles of Lasers are presented. In the last section, the basic concepts of thermodynamics are presented and the Laws of Thermodynamics are formulated, in combination with elementary applications.

Semester: 2

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Mechanical waves in 1-dimension	Mechanical waves in continuous elastic media in one dimension. Wave equation in an elastic string. Transverse and longitudinal waves. Traveling waves: energy propagation, characteristic impedance of elastic media, reflection and transmission of traveling waves at a boundary. Standing waves: normal modes in a continuous elastic	12

#	Title	Description	Hours
		medium, Fourier analysis. Wave packets, phase and group velocity, dispersion	
2	Mechanical waves in 2-dimensions	Mechanical waves in two dimensions. Waves in elastic membranes, surface waves in liquids.	4
3	Mechanical waves in 3-dimensions	Mechanical waves in three dimensions. Acoustic waves. Electromagnetic Waves. Polarization. Reflection. Refraction.	3
4	Optics	Basic laws of optics, geometrical optics. Coherent optical radiation: Interference of coherent sources, Diffraction.	3
5	Introduction to Quantum mechanics	Principles of Quantum Mechanics and Schroedinger equation. Bound quantum systems and discrete energy spectrum. Basic operational principles of Lasers.	6
6	Introduction to Thermodynamics	Temperature and Heat (Temperature – Thermal equilibrium, Temperature scales. Thermidometry – Phase changes, Heat transfer mechanisms). Thermal Properties of Matter. (State Equations, Kinetic – Molecular model of an Ideal Gas, Molecular velocities, Heat Capacities). First Thermodynamics Law ($\Delta U=Q-W$) and Thermodynamic Transitions. Second Thermodynamics Law and Carnot cycle. Entropy. Applications of Thermodynamics Laws.	11

Learning Objectives

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

- treat quantitatively the wave effects of 1-dimension, regarding both traveling (reflection and transmission coefficients) and standing waves (normal modes and Fourier analysis);
- assimilate the common conceptual and formalistic features of wave phenomena through the transition to two and three dimensions as well as the effect of the energy conservation and of the wave-topology to the dependence of the amplitude on the distance to the source;
- correlate the wave and geometric characteristics of light as an electromagnetic wave, with the reflection and refraction processes as well as the phenomena of interference and diffraction;
- understand the need to change the context of the description of the atomic-level phenomena and the fundamental principles of quantum mechanics that lead to the stability of atomic systems and the discrete energy spectrum, with an application on the laser systems and the principle of their operation;
- understand the fundamental concepts of thermodynamics and their relationship to the thermal properties of matter;
- use the fundamental laws of thermodynamics for basic thermodynamic calculations.

4.3 3rd Semester

English Language III

Course Description

The English language course aims at familiarizing students with language use in a variety of social contexts and communicative tasks (development of linguistic awareness). A range of practical activities in advanced syntactic structures are regularly provided along with activities designed to develop understanding and production of both spoken and written language in social, academic and professional settings. The level attained at the end of the semester is equivalent to C1, as it is defined by the Common European Framework of Reference for Languages.

Semester: 3

Teaching hours: 2

Strength Of Materials

Course Description

The aims of the course are to teach students the basic topic of the subject and to develop the students analytical and problem-solving abilities in the following topics: Generalized Theory of Pure Bending, Eccentric Axial Loading, Core of a Cross Section, Shear Stresses in Beams, Shear Stresses in beams of Thin-walled Cross Sections, Shear Centre, Energy Methods in Structural Mechanics, Failure Criteria of Materials (Tresca, Misses, Mohr – Coulomb).

Semester: 3

Teaching hours: 2

Course Units

#	Title	Description Hours
1	Pure Bending in Built-up Beams (built-up cross sections)	3
2	Doubly symmetric beams with skew loads. Generalized Theory of Pure Bending	3
3	Eccentric Axial Loading. Neutral Axis, Core of a cross Section.	3
4	Eccentric Axial Loading. Neutral Axis, Core of a cross Section.	3
5	Shear Stresses in Beams (Shear Stresses due to Bending). Shear Flow.	3
6	Shear Stresses in beams of Thin-walled Cross Sections (open and closed cross sections). Shear Centre of Thin-walled Open Sections	

#	Title	Description Hours
7	Beams under Combined Axial, Bending, Torsional Loading	3
8	Introduction to Energy Methods in Structural Mechanics. Strain Energy and Complementary Energy. Conservation of Energy.	3
9	Energy Methods (Castiglianos' Theorems, Reciprocal Theorems)	3
10	Energy Methods (Principle of Virtual Work, Introduction to the Force Method)	
11	Buckling	3
12	Failure Criteria of Materials (Tresca, Misses, Mohr – Coulomb)	3
13	Failure Criteria of Materials (Tresca, Misses, Mohr – Coulomb)	3

Learning Objectives

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

- calculate the distribution of normal and shear stresses within arbitrary –non-symmetric cross sections of structural members (e.g. beams, columns, etc.) when loaded under with axial and skew bending;
- calculate neutral axis, as well as the core of the cross section;
- estimate the shear flow of an arbitrary open or closed thin-walled cross-section;
- determine the elastic strain energy of a structural member due to combined axial-bending-torsional loading;
- determine displacements of linear elastic structural member using energy methods;
- calculate the buckling load of structural members for various boundary conditions;
- estimate/guess potential points of failure in simple structural members using failure criteria.

Numerical Analysis

Course Description

[Missing information in the English transcript]

Semester: 3

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	*[Missing information in the English transcript]*	*[Missing information in the English transcript]*	5×4=20

#	Title	Description	Hours
2	*[Missing information in the English transcript]*	*[Missing information in the English transcript]*	2×4=8
3	*[Missing information in the English transcript]*	*[Missing information in the English transcript]*	2×4=8
4	*[Missing information in the English transcript]*	*[Missing information in the English transcript]*	2×4=8
5	*[Missing information in the English transcript]*	*[Missing information in the English transcript]*	2×4=8

Learning Objectives

[Missing information in the English transcript]

French Language III

Course Description

The aim of the course is to familiarize students with the use of the French language through the study and analysis of scientific texts for academic purposes. Also, it focuses on students' exercise in scientific papers writing techniques so that they could cope to the modern scientific needs at undergraduate and postgraduate level. The course is supported by the instructor's appropriate teaching material which includes selected readings and "My Courses" NTUA platform of asynchronous tele-education.

Semester: 3

Teaching hours: 2

Geodesy (surveying)

Course Description

Introduction, subject and purpose of surveying. Basic concepts (reference surfaces and coordinate systems, measured quantities, maps and topographic plans). Planar Cartesian coordinate reference systems, fundamental problems. Distance measurements (tapes and EDM, measuring methods, calculations, corrections and reductions). Direction – Angle measurements (total stations, measuring methods, calculations). Height differences measurements, levelling, types of heights (measuring methods of height differences, instruments, optical and digital levels, calculations). Site survey, plan drawing, stake out construction, Hellenic Geodetic Reference System 1987 -Global Navigation Satellite System, basic principles, methodology, observations analysis Exercises and problems are given on all the above topics.

Semester: 3

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction – Reference surfaces	Introduction-History- reference surfaces (Geoid, Ellipsoid, sphere, plane)- Reference coordinate Systems (X, Y, Z - φ, λ, h - Φ, Λ, H - x, y, z)	1×4=4
2	Fundamental definitions	Basic definitions – Triangle geometry – measurement units	2×4=8
3	Distances and directions measurements	Basic principles for the distances and directions measurement – Instrumentation	1×4=4
4	Laboratory of Instruments I	Total stations	1×4=4
5	Measurements of heights	Basic principles- measurement methods (spirit levelling, trigonometric levelling)- Instrumentation	1×4=4
6	Laboratory of Instruments II	Optical and digital Levels	1×4=4
7	Stake out of constructions	The methodology of stake out constructions by conventional and CNSS systems	1×4=4
8	Laboratory of Instruments III	GNSS receivers	1×4=4
9	HGRS '87	Definition of the Hellenic Geodetic Reference System 1987, presentation of its applications	1×4=4
10	Site Survey	General principles – Methodology –Calculation – Accuracy	2×4=8
11	Plan drawing	Methodology of plan drawing, appropriate references.	1×4=4

Learning Objectives

The course provide knowledge on: The fundamental principles of measurement and calculations of the points coordinates (x, y, H) The use and usefulness of the geodetic measurements and the properties plan drawing. All the modern methods which are used for the documentation and the Stake out of constructions The use of modern geodetic instrumentation (total stations, levels, GNSS receivers).

Dynamics of the rigid body

Course Description

The course aims to teach students the basic topic of the subject and to develop the students analytical and problem-solving abilities in the following topics: Kinematics of a particle, Kinematics of a rigid body, Kinetics of a particle and for a system of particles, Kinetics of a rigid body, Vibrations, Lagrange's equations, Hamilton's principle.

Semester: 3

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Kinematics of particles (curvilinear motion)		3
2	Kinematics of particles (coordinate systems: Cartesian, normal-tangential systems)		3
3	Kinematics of Rigid Bodies (translation, rotation about an axis, planar kinematics)		3
4	Kinematics of Rigid Bodies (General motion, Relative motion)		3
5	Dynamics (Kinetics) of particles (mass, force, Newton's Law)		3
6	Dynamics (Kinetics) of particles (Work-Energy, Impulse - Momentum)		3
7	Dynamics (Kinetics) of system of particles (Newton's Law, Work-Energy, Impulse – Momentum)		3
8	Dynamics (Kinetics) of Rigid Bodies (planar dynamics, Newton's Law, Euler's equations of motion		3
9	Dynamics (Kinetics) of Rigid Bodies (Work, Energy, Momentum, Moment of Momentum)		3
10	Vibrations (free vibrations of mass spring systems)		3
11	Vibrations (Force vibrations of damped systems)		3
12	Lagrange Equations, Hamilton's Principle		3
13	Lagrange Equations, Hamilton's Principle		3

Learning Objectives

With the successful completion of the course, the students will be able to formulate the equations of motion of a rigid body moving in 2D or 3D space using various methods of analysis. Furthermore, the course is fundamental for further studies in structural dynamics, seismic design and structural control.

Laboratory on Constructions - Geotechnics

Course Description

Experiments in material science and engineering. Mechanical behaviour under static and dynamic loading. Engineering stress and strain calculations.

Semester: 3

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Safety and Health	Marking and instructions. Precautions and means of personal protection. First Aid.	1×3=3
2	Reinforced Concrete-Two Support Beam	Four point bending to a beam made of reinforced concrete, in such a way that shear damage occurs. Exhaustion of bearing capacity in shear and calculation of stresses and strains before yield. Study of the brittle (undesirable) case of failure. Determination of stiffness before yield.	1×3=3
3	Reinforced Concrete-Two Support Beam	Four point bending to a beam made of reinforced concrete, in such a way that flexural damage occurs. Exhaustion of bearing flexural capacity in and calculation of stresses and strains after yield. Study of the ductile (desirable) case of failure. Determination of stiffness after yield.	1×3=3
4	Soil- Sand at various densities	Measurement of pore water pressure in soil samples at rest and under steady-state groundwater flow. Experimental setup to induce soil liquefaction in the laboratory. Experimental setup to study Darcy's law. Measurement of the hydraulic conductivity/permeability k=(m/s) of sand at various densities. Study of flow problems in soils due to groundwater movement; soil permeability calculations. Critical hydraulic gradient introducing quick condition and piping in sandy soils compared with soil liquefaction.	1×3=3
5	Soil- Sand and Retaining Wall	Potential collapse conditions of retaining walls. Mobilization of active and passive pressure distribution with wall translation. Simplified pressure distribution at limiting condition. Experimental setup for the study of the degree of wall soil interaction, with measurement of loads and displacements behind a retaining wall.	1×3=3
6	Structural systems	Bearing systems. Beams, frames, arches and grillages. Degrees of freedom. Dynamic base excitation with various frequencies recording of the response. Resonance curve of a single degree of freedom	1×3=3

#	Title	Description	Hours
		(SDOF) structure. Dynamic characteristics of a SDOF structure by comparing input motion and response.	
7	Steel Structures – Simple steel building	Basic structural elements of a simple steel roofed structure. Assembling a steel building. Familiarization with basic steel elements (rolled profiles, bolts etc). Tolerances during construction. Construction of steel structures. Fundamentals of designing steel bearing systems	1×3=3
8	Steel Structures – Steel cantilever	Loading. A) Closed hollow section with medium bending strength and high shear strength B) Open section (double tee) with high bending strength and low torsional strength C) Vulnerable cross-sections to lateral buckling. Cross-section of beams under bending and torsion.	1×3=3
9	Five story steel scaled model	Earthquake excitation in one direction of a five story steel structure using the earthquake simulator. Three different time histories will be applied. Seismic elastic behaviour of a multi storied building. Floor acceleration. Relation between absolute acceleration and relative displacement of a floor. Scaled model vs prototype structure.	1×3=3

Learning Objectives

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

- measure engineering quantities of structural members, structures and soil;
- verify the calculated results using theoretical background;
- utilize their knowledge from other courses.

Computer-based Solution Methods

Course Description

Basic principles on programming, introduction to interpreted languages and extensive presentation of the Matlab computational package, Matlab language and Matlab functions. Semester project: choice among many suggested projects related to the fields of the departments of: Structural Engineering, Water Resources and Environmental Engineering, Transportation Planning and Engineering, Geotechnical Engineering, Construction Engineering and Management. The project is developed by groups of 2/3 students.

Semester: 3

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction to Programming	Introduction to Programming. Algorithms and flow charts. Introduction to MATLAB integrated environment.	2×2=4
2	Matlab functionality and functions	Matlab functionality and Matlab functions. Program components. M-files: Script and function files. Program debugging.	2×2=4
3	Matlab functions (1)	Matlab functions. Variables (global/local).	2×2=4
4	Matlab functions (2)	Functions, sub-functions, nested functions, anonymous functions.	2×2=4
5	Use of matrices and operations on matrices	Use of matrices, vectors and lists. Operations on matrices, vectors and lists.	2×2=4
6	Conditions/conditional execution	Conditions, conditional statements and conditional execution.	2×2=4
7	Matlab graphs (1)	Matlab graphs (1): statements plot, figure, hold on, etc., close all.	2×2=4
8	Matlab graphs (2)	Advanced use of graphs in Matlab (3D graphs, statements meshgrid, mesh, surf, etc.).	2×2=4
9	Loop control statements	Loop control statements: while & for. Use of vectors to avoid loop statements. Fast input statements of external files.	2×2=4
10	Input/output statements	Input/output statements: input of external files of various formats, integration method, applications.	2×2=4
11	Strings - Structures	Strings-Structures: strings, output to files of various formats, structures, applications.	2×2=4
12	Symbolic operations, integrals, derivatives, differential equations	Symbolic operations, integrals, derivatives, differential equations: Symbols and symbolic operations, symbolic integrals, symbolic derivatives, symbolic solution of differential equations, applications.	2×2=4
13	Data modelling	Data modelling: Curve fitting to data, curve fitting in Matlab, surface fitting in Matlab, applications.	2×2=4

Learning Objectives

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

- know basic programming principles;
- realize the value of computers to civil engineering;
- understand how computers work;

- structure small computer programs for engineering applications;
- compute through computer programming numerical-technical problems of civil engineering.

Environmental Engineering

Course Description

Introduction to the basic ecological principles, physical, chemical and biochemical processes in the aquatic environment and reactors. Types of microorganisms - metabolism (aerobic, anoxic, anaerobic) - kinetics. Flow and mixing regimes in reactors (batch, continuous flow completely mixed and plug flow). Transport phenomena in the aquatic environment. Disposal of liquid wastes in water recipients, study of self-purification capacity and quantitative assessment of impacts (oxygen depletion in rivers, eutrophication in lakes, microbial pollution of bathing waters). Principles of water and wastewater treatment in compliance with legal requirements and description of related treatment plants. Reuse and utilisation of sewage and sludge with emphasis on agricultural practices. Introduction to solid waste management.

Semester: 3

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction to environmental engineering	Scope of environmental engineering. Introduction to microorganisms metabolism. Chemical composition of microorganisms. Microorganisms categories.	1×3=3
2	Microorganisms – metabolism – growth kinetics	Microbial growth kinetics. Microorganisms growth curve. The concept of limiting factor. Aerobic, anaerobic, anoxic metabolism, nitrification, denitrification, photosynthesis. Problem solving.	2×3=6
3	Water pollution and self-purification capacity of water recipients	Transport phenomena in the aquatic environment. Assessment of the self-purification capacity and environmental impact assessment due to the disposal of liquid wastes in water recipients (oxygen depletion in rivers - simple Streeter-Phelps model, eutrophication in lakes - Vollenweider model, microbial pollution of bathing waters Problem solving.	5×3=15
4	Introduction to wastewater treatment	Wastewater characteristics, national legislation, flow and mixing regimes in reactors, typical wastewater treatment system, activated sludge system. Problem solving.	2×3=6
5	Introduction to water treatment	Water quality characteristics, national legislation, typical water treatment system (coagulation, flocculation, sedimentation, filtration, disinfection). Problem solving.	2×3=6

#	Title	Description	Hours
6	Introduction to solid waste management	Introduction to solids waste management. Production and characteristics of solid wastes. Alternative solid wastes management practices. Sanitary landfills.	1×3=3

Learning Objectives

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

- identify the basic water quality problems;
- understand the basic properties/functions of microorganisms;
- know the basic processes adopted in water and wastewater treatment;
- understand issues regarding solid wastes management;
- calculate the environmental impacts from the disposal of liquid wastes in the water recipients;
- perform initial design calculations of water and wastewater treatment facilities.

4.4 4th Semester

English Language IV

Course Description

This course focuses on developing students' context-based skills in English and their communicative competence by covering a wide range of topics related to specific disciplines of engineering i.e., civil and surveying engineering, architecture etc. (e.g., planning, designing and constructing buildings and other structures, materials and types of constructions, construction of bridges or tunnels, airports or harbours, earthquakes among others). This course aims at increasing students' vocabulary and familiarizing them with a variety of text types and discourse environments while it involves them in using the language for a variety of purposes. The main focus is to enable students develop essential professional language and increase their competence in using this new language when dealing with a variety of technical texts.

Semester: 4

Teaching hours: 2

French Language IV

Course Description

The course aims at introducing students to francophone scientific environments. Specifically, students are familiarized with selected Francophone bibliography, scientific readings and study material found in authentic sources (university textbooks, articles, dictionaries and other academic papers and journals). In addition, students are involved in a number of complementary activities in order to correspond to their overall academic needs (study abroad through the Erasmus program for postgraduate or doctoral studies in Francophone countries, participation in conferences, seminars and meetings conducted in French language). The course is supported by the instructor's appropriate teaching material which includes selected readings and "My Courses" NTUA platform of asynchronous tele-education.

Semester: 4

Teaching hours: 2

Surveying Engineering Applications

Course Description

Geodetic control networks. The concept of control network. Geodetic control network densification methods (Intersection, Resection, Traversing). Satellite positioning (GNSS). Traversing. Traverse types. Land Surveying. Surveying small areas. Surveying large areas. Surveying buildings, monuments and archaeological sites. Use of satellite techniques in surveying engineering. Town planning implementation. Volume calculations. Setting out. Profiles and cross sections. Methods and techniques for the determination of deviations, movements and deformations of technical works and constructions.

Semester: 4

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Geodetic Networks - Traversing	Traversing – Types of traverses – Field observations – Satellite (GPS) observations - Traverse adjustment – Coordinates of traverse stations.	2×3=6
2	Topographic surveys	Topographic surveys – Methods - Stadia and electronic surveying - Topographic plans and maps Use of GPS methods in Surveying.	2×3=6
3	Topographic surveys	Geometric documentation of buildings and archaeological sites.	2×3=6
4	Topographic surveys	Use of Topographic plans and maps.	1×3=3
5	Height determinations	Levelling – Special methods in trigonometric levelling – Digital terrain models.	2×3=6
6	Use of topographic surveying	Sections and Cross sections – Volumes – Volume Computations – Setting out (lines, angles, circular curves).	2×3=6
7	Health monitoring of constructions	Methods and techniques of Determination in deformations of civil and mechanical engineering structures.	2×3=6

Learning Objectives

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

- be aware of the basic principles of geodetic networks;
- be trained to successfully accomplish the topographic survey of a property;
- have understood the meaning and the effectiveness of geodetic methods in the monitoring of civil and mechanical engineering structures.

Soil Mechanics I

Course Description

Introduction, applications of soil mechanics in civil engineering. The nature of soil, types of soil, density, water content, Atterberg limits, subsurface soil investigation. Stresses and strains in soil elements, description of the stress state at a point with the Mohr's circle, total and effective stresses, the "effective stress principle", geostatic stresses and stress changes due to externally applied loads (under plane strain and axisymmetric conditions). Phenomenological and microscopic description of soil deformation mechanisms. The triple role of the fluid phase. Stress-strain relationships under different loading conditions: one-dimensional compression, cylindrical (tri-axial) compression, simple shear, torsion. Shear strength of a soil element, Mohr-Coulomb failure criterion. Undrained loading: excess pore pressure, stress-strain relations under various loading conditions, undrained shear strength of soils. Laboratory: Demonstration of common soil mechanics tests used to determine physical and mechanical properties.

Semester: 4

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction - Physical characteristics of soils		2×4=8
2	Stresses in the ground - Geostatic stresses - Soil deformation		1×4=4
3	Effective stress principle - Stress -strain relationships - Linear elasticity		2×4=8
4	One-dimensional deformation (oedometer test)		2×4=8
5	Transmission of stresses in the ground		1×4=4
6	Shear strength of soils - Measurement of shear strength parameters		3×4=12
7	Soil behaviour under undrained conditions		2×4=8

Learning Objectives

Knowledge of basic principles of Soil Mechanics and applications in simple problems of settlement and bearing capacity.

Applied Economics

Course Description

Introduction to microeconomic theory. Supply and demand. Equilibrium – Price formation. Demand theories: Consumer behaviour. Theory of absolute utility. Theory of cardinal utility. Consumer equilibrium. Demand in the construction industry. Theory of production: Production function. Short-run, long-run period. Law of diminishing returns. Returns to scale. Supply in the construction industry. Clients-Contractors, subcontractors. Partnering. Construction projects. On-site production, off-site production. Theory of production cost: Costs of the firm. Costs of the construction firm. Financial accounting: Financial accounting and its use. Basic accounting principles. Cost accounting – cost accounting methods. Financial statements: Income Statement, Balance Sheet, Cash Flow Statement. Market types: Perfect competition, monopoly, monopolistic competition, oligopoly. Types of market structure in the construction industry. Performance evaluation: Efficiency: Technical and allocative efficiency. Performance evaluation of construction firms and projects: Multi-dimensional evaluation and ratio analysis. Case study.

Semester: 4

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction to the course subject	Introduction to microeconomic theory. Supply and demand. Equilibrium – Price formation.	2×3=6
2	Demand theories	Consumer behaviour. Theory of absolute utility. Theory of cardinal utility. Consumer equilibrium. Demand in the construction industry.	2×3=6
3	Theory of production	Theory of production. Short-run, long-run period. Law of diminishing returns. Returns to scale. Supply in the construction industry. Clients-Contractors, subcontractors. Partnering. Construction projects. On-site production, off-site production.	3
4	Theory of production cost	Costs of the firm. Costs of the construction firm.	3
5	Financial accounting	Financial accounting and its use. Basic accounting principles. Cost accounting – cost accounting methods. Financial statements: Income Statement, Balance Sheet, Cash Flow Statement.	2×3=6
6	Market types	Perfect competition, monopoly, monopolistic competition, oligopoly. Types of market structure in the construction industry.	3×3=9

7	Performance evaluation	Efficiency: Technical and allocative efficiency. Performance evaluation of construction firms and projects: Multi-dimensional evaluation and ratio analysis. Case study	2×3=6

Learning Objectives

After the successful completion of the course the students will know the basic principles of microeconomics with emphasis in the construction industry and specifically, issues that deal with demand and supply, consumer behaviour, production theory, firm behaviour, market types and the efficiency measurement in construction industry. Moreover, they will have familiarized themselves with the basic financial terms and principles that they will face in their working environment.

Fluid Mechanics

Course Description

Knowledge of the fundamental laws of fluid mechanics and ability to solve problems regarding stagnant and fluids in motion. Hydrostatic forces on flat and curved surfaces and submerged bodies. Computation of flow parameters of ideal and real fluids. Computation of the flow using control volume analysis. Laminar flow, introduction to turbulent flow and boundary layer. Velocity distributions and friction coefficient.

Semester: 4

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Fluid properties.	1×4=4
2	Hydrostatics	Hydrostatics equation, pressure distribution in homogeneous and density-stratified fluids, manometers, pressure forces on flat and curved surfaces, Archimedes principle, buoyancy force on submerged bodies.	2×4=8
3	Kinematics	Eulerian and Lagrangian flow description. Streamlines, streaklines, pathlines and timelines. Deformation of fluid elements, vorticity and circulation.	1×4=4
4	Fundamental laws of fluid mechanics	Differential analysis of the flow. Mass, momentum and energy conservation principles, continuity and Navier Stokes equations.	1×4=4
5	Control volume analysis	Reynolds transport theorem, continuity, momentum and energy equations. Energy and hydraulic grade lines, hydraulic machinery, pumps and turbines.	2×4=8

6	Ideal fluid and applications	Euler and Bernoulli equations, irrotational flow, potential and stream function, Laplace equation, Pitot tube. Flow separation and cavitation. Flow discharge through orifices, trajectory of free jets, flow over weirs and under sluice gates.	2×4=8
7	Viscous fluids	Reynolds number, laminar and turbulent flow. Lift and drag forces on submerged bodies in a moving fluid.	1×4=4
8	Laminar flow	Couette and Poiseuille flow.	1×4=4
9	Turbulent flow in pipes, boundary layer, velocity distribution, energy loss	Laminar and turbulent boundary layer, displacement and momentum thickness, boundary shear stress. Velocity distributions in turbulent pipe flow. Darcy-Weisbach equation, friction energy losses. Friction coefficient in turbulent and laminar flow, Colebrook-White equation, Moody diagram.	2×4=8

Learning Objectives

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

- calculate pressure forces on flat and curved submerged surfaces;
- calculate flow velocity and pressure distribution using control volume analysis in open and in closed (confined) flow fields, as well as the dynamic loads on structures that contain or are submerged in the moving fluid;
- calculate flow rate through orifices, over weirs and under sluice gates;
- calculate lift and drag forces on submerged bodies in a moving fluid;
- calculate the velocity and shear stress distribution in laminar flow fields;
- calculate friction energy loss and draw the energy (EGL) and hydraulic grade lines (HGL) in closed systems.

Construction Site Organization and Safety - Construction Equipment

Course Description

Introduction to the production of engineering projects, construction equipment, basic concepts of Mechanical Engineering, quantity take-off & measurement, on the design of construction sites, organization and staffing of construction sites. Health and Safety (OHSAS 18001 Essential Requirements, Legislative Framework, Safety and Health Plan & File according to the Greek legislation, Employees & Employee Responsibilities), the role of the Safety Engineer. Operational analysis and costing of basic construction works (earthworks, soil compaction, lifting, concrete & asphalt mix - Practical applications.

Semester: 4

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduction – The knowledge area of Construction Engineering & Management, Description & requirements of the course, Introduction to the production of engineering projects.	1×3=3
2	Construction Equipment	Construction Equipment - categories, main operations of earthmoving machines, selection. Cost of construction equipment (procurement, replacement, depreciation).	2×3=6
3	Elements of Mechanical Engineering	Basic elements of mechanical engineering	1×3=3
4	Quantity Take-Off & Methods of Measurement	Blueprints – dimensions, measurement, units, unit conversion, measurement of basic construction works.	1×3=3
5	Construction Site Organization	Design and dimensioning of construction sites - Organization of a construction site	2×3=6
6	Health & Safety	Health and Safety (OHSAS 18001 Essential Requirements, Legislative Framework, Safety and Health Plan & File according to the Greek legislation, Employees & Employee Responsibilities), the role of the Safety Engineer.	2×3=6
7	Operational Analysis of construction work	Operational Analysis – Basic concepts – theoretical relations – approximate productivity estimation diagrams – Excavator- Truck, bulldozer– scraper & scraper & bull. Cost estimations. Practical examples	4×3=12

Learning Objectives

[Missing information in the English transcript]

Probability and Statistics

Course Description

The meaning of probability. Axioms of probability. Conditional probability. Independent events. Random variables. Density and cumulative distribution functions. Parameters of distributions. Generating and characteristic functions. Special discrete and continuous distributions. Functions of random variables. Central limit theorem. Random sample and sampling distributions. Estimation of parameters. Point estimation. Interval estimation. Hypothesis testing. Goodness of fit tests. Contingency tables. Simple and multiple linear regressions.

Semester: 4

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Random experiments, Historical review, Set theory.	2
2	Introduction to Probability	Sample space, Events, Definitions of probability, Axioms of probability, Conditional probability, Independence, Elements of combinatorics, Exercises.	10
3	Univariate Random Variables	Discrete and continuous random variables, Distribution function, Probability mass function, Probability density function, Exercises.	4
4	Moments of Random Variables	Expectation, Variance, Standard deviation, Moments, Exercises.	4
5	Specific Discrete Distributions	Bernoulli, Binomial, Geometric, Negative Binomial, Hypergeometric, Poisson, Exercises.	4
6	Specific Continuous Distributions	Uniform, Normal, Exponential, Gamma, Weibull, X2, Exercises.	4
7	Functions of Random Variables	Discrete case, Continuous case, Distribution of the sum of random variables, Distribution of the maximum and minimum, Exercises.	4
8	Central Limit Theorem	Approximate distribution of independent and identically distributed random variables, Approximate distribution of the sample mean of independent and identically distributed random variables, Approximation of Binomial by the Normal distribution, Exercises.	4
9	Introduction to Statistics	Introduction to the problem. Random sample and sampling distributions. Elements of descriptive statistics.	2
10	Point Estimation	Unbiasedness, Method of moments, Method of maximum likelihood, Exercises.	8
11	Confidence Intervals	Introductory notions and definitions, Interpretation of a confidence interval, Applications based on the normal distribution, Approximate confidence intervals, Connection to hypothesis testing, Exercises.	6

Learning Objectives

The module Probability - Statistics delivers an introduction in the modelling and analysis of stochastic systems. Its aim is to familiarize the students with the notions of random variables, distributions and parameters of them, as well as to develop skills in stochastic quantitative calculations. Additionally, methods of estimating unknown quantities are introduced, using Statistical techniques, with the help of a random sample.

Computer Programming

Course Description

Advanced general purpose programming with object-oriented methods and the Python programming language, and advanced use of complex data structures. Introduction to MPI parallel programming and server side network programming. Application to the development of integrated software with graphical user interface, complex numerical methods and graphs. Interpreted and compiled programming languages. Development of fast binary code with object-oriented Fortran 2003 and parallel Fortran 2008.

Semester: 4

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction to Python	Introduction to the necessary tools, show case of tools' installation, introduction to Python, variables, expressions, scalar types, conditional execution.	1×3=3
2	Loops, functions, and array and matrix arithmetic	Loops, generators, flow control commands. Array and matrix arithmetic. Function definitions and calls. Input and output arguments. Default arguments. Variable number of arguments. Applications.	1×3=3
3	Complex data types & object-oriented programming	Pyzo integrated environment. Variables, tuples, lists, sets, dictionaries. Examples. Classes and objects. Python built-in objects. Methods and members. Inheritance. Polymorphism. Examples.	1×3=3
4	Runtime error manipulation and exceptions	Error propagation in nested functions. Error control with exceptions. Exception types. Raising Exceptions. Debugging with Pyzo. Examples.	1×3=3
5	Creation and manipulation of numerical data	Matrix computations and numpy. Scientific computation with scipy. Complex graphs with matplotlib. Compatibility with Matlab. Examples.	1×3=3

6	Graphical user interface (GUI)	Tkinter graphical user interface. Master window. Widgets. Display and input of text. Fonts. Geometry manager - grid. Menu. Displaying error messages. GUI and object-oriented programming. Examples.	1×3=3
7	Graphical user interface (GUI) 2	GUI and logic separation. Read and write files with GUI. Drawing of vector graphics, lines, circles etc. Automatic geometry resizing. Multi-line text. Scrollbars. Widget containers. New classes of widgets. Multiple windows.	1×3=3
8	Introduction to parallel programming	Serial and parallelizable computations. Parallel system architecture. MPI parallel system. Execution of same code instances in multiple cores. Execution differentiation with Rank. Instance communication with send/recv. Broadcast and Reduce. Examples.	1×3=3
9	Generators and paths	Generator expressions. Generators. Nested generators. Built-in generators and generator expressions. File paths. Directory paths. Unified use in Windows, Linux, MacOS. Path methods. Nested paths. Examples.	1×3=3
10	Introduction to Internet programming	Internet, WWW, HTTP, URL. Clients and servers. Links. Brief description of HTML. Creation of server with Python bottle. Assigning web pages to functions. Grouping of web pages. Printing HTML from functions. Examples.	1×3=3
11	Introduction to Fortran	Interpreters and compilers. Advantages and disadvantages. Fortran variables. User defined and platform independent precision. Flow control commands. Matrices and multidimensional arrays. Matrix operations and matrix functions. Dynamic size matrices. Numerical libraries. Compiled binaries. Examples.	1×3=3
12	Object oriented programming in Fortran	Modules. Common variables. Public and private functions. Function overloading. New data types. Class definition. Inheritance and polymorphism. Examples.	1×3=3
13	Fortran parallel programming and C interoperability	Multiple instances of single program. Integrated parallel processing with Fortran statements. Communication with co-arrays. Instances synchronization with SYNC and NOTIFY, QUERY. Avoiding side effects with critical regions. Examples. Interoperability with C. Compatible variable types. Calling C functions from Fortran. Calling Fortran functions from C. Interfaces. Calling C functions from Python, calling Fortran functions from Python.	1×3=3

Learning Objectives

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

- possess deep and pluralistic knowledge on computer programming (interpreted and compiled languages);
- realize the value of computers to civil engineering;
- understand how computers work, and the confines and limitations of programs and PCs in general;
- structure extensive and integrated general-purpose computer programs;
- compute through computer programming any civil engineering problem.

Structural Analysis of Statically Determinate Structures

Course Description

Structural analysis of statically determinant structures is the foundation of understanding Structural Mechanics. Therefore, this course forms the basis in Civil Engineering studies and the forthcoming professional career. The course offers a systematic study the internal forces and deformations of structural systems, the behaviour of which is governed by the equilibrium, which is the most fundamental principle of Engineering.

Semester: 4

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Introduction to structural analysis. Rigid formations and structures. Types of loading. Support types. Equilibrium equations. Structural determinate systems.	4
2	Two dimensional structures. Statical indeterminacy.	Plane frames. Composition of a structure. Calculation of statical indeterminacy.	4
3	Geometric instability	Definition and ways to assess geometric instability. Assumptions of small deformations' theory.	4
4	Internal forces, fundamental structural systems.	Internal forces, bending theory of beams, Moment, shear and axial force diagrams for simply supported beams, cantilevers and frames. Qualitative diagrams.	4
5	Composite structural systems	Structures with internal releases (hinges). Gerber-type beams and frames.	4

6	Three-hinged arches.	Three-hinges' arches and frames	4
7	Structural systems with no bending	Cable-beam structural systems. Trusses. Cables.	4
8	Special structures.	Structures with lifting systems. Suspended structural systems.	4
9	Energy principles. The principle of virtual work.	The principle of virtual work in beam-type structures. Euler-Bernoulli and Timoshenko theory.	4
10	Calculation of displacements	The unit load method. Calculation of displacements of statically determinate structures.	4
11	Influence lines	Influence lines definition. Influence lines calculation of internal forces. Simply supported and overhanging beams.	4
12	Influence lines of composite structural systems.	Influence lines of Gerber-type beams and frames. Extreme values of internal forces – Envelopes.	4
13	Three dimensional structures	Out of plane loading of two-dimensional framed structures. Calculation of internal forces and deformations of simple girders.	4

Learning Objectives

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

- understand equilibrium;
- understand the behaviour of determinate structures;
- draw bending, shear and axial force diagrams of determinate structures;
- understand the principle of virtual work.

4.5 5 th Semester

Geometric Design of Roads

Course Description

Introduction to roads geometric design as well as details related to design parameters per design stage. Means for drafting a road design project in two-dimensional environment as well as critical elements required during its three-dimensional assessment. Simulation of the vehicle in the process of determining control design values. Particular emphasis is given on qualitative and quantitative indicators directly related to safety and operational aspects of road design.

Semester: 5

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Concept of horizontal, vertical and cross-sectional design, road functional classification.	1×4=4
2	Vehicle dynamics aspects, friction mechanisms, speed values	Forces applied on the vehicle (aerodynamic, tire - road contacting force, vehicle weight), tractive - braking forces, critical speed values, longitudinal and lateral friction.	1×4=4
3	Vehicle simulation in road design	Existing vehicle dynamics approach during the determination of control road geometric parameters, assumptions, determination of minimum horizontal radius - speed for skidding and roll-over, climbing lanes.	1×4=4
4	Horizontal design	Road horizontal design elements, tangent, transition curve – types, circular arc, control values, safety criteria (qualitative road assessment based on design consistency).	2×4=8
5	Vertical design	Road vertical design elements, longitudinal grades, crest – sag vertical curves, control values, road longitudinal profile.	1×4=4
6	Cross – sectional design	Crown-sloped and single-sloped pavements, pavement rotation, pavement edge-line grades, cross – sectional and pavement edge-line diagrams.	1×4=4
7	Horizontal – vertical clearance, cross sections	Dimensional definition of cross sections (horizontal – vertical clearance), road users, typical cross sections, cross sections elements, lateral configurations – road side equipment (in general), pavement widening - enlargements, road drainage issues - necessity to modify vertical profile, cross - sectional diagrams.	2×4=8
8	Visibility	Geometric sight distance (stopping, passing, decision, intersection), psychological sight distance (depth of the driving space, of which the driver supposes to have it completely registered), visibility diagrams.	1×4=4
9	Modern trends in road design	Road design in 3D, current concepts in road design (speed, cross - sections).	1×4=4
10	Road design stages	Feasibility study, preliminary design, pre-final design, detailed design, backgrounds - precisions.	1×4=4

11	Introduction to safety aspects during road design	Introduction to safety aspects during road design, project delivery.	1×4=4

Learning Objectives

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

- perceive the design process and the degree of detail per stage of a road design project;
- understand the limitations and commitments underlying the control values of critical geometric parameters;
- apply basic principles and methods related to safe and operational road design;
- assess combinations of critical design parameters regarding the quality of the design;
- tackle common problems during road geometric design process.

Soil Mechanics II

Course Description

Application of elastic continuum theory: stresses and strains in soil masses under external loading. Plane-strain and axis-symmetric loading. The St. Venant principle. Horizontal earth pressures under different loading conditions. Rankine and Coulomb methods. Gravity retaining walls. The role of elastic deformations. Limit equilibrium methods in soil mechanics. Slope stability under drained and undrained conditions. Ultimate load of foundation (bearing capacity). Ground water flow in one dimension. Evolution in time of excess pore water pressures and consolidation of a clay layer due to vertical external loading.

Semester: 5

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Applications of Soil Mechanics II in Geotechnical Engineering.	1×4=4
2	Elements of Stress Analysis	Mechanical stress-strain behaviour of soil. Stresses induced by the self-weight of soil. Stresses and strains in soil masses under external loading. The states of plane strain and axisymmetric deformation. The St. Venant principle. Stress distribution in a two-layered half-space.	2×4=8
3	Lateral Earth Pressure	Active and Passive earth pressure: The transition from elasticity to yielding. The Rankine's theory for estimating the lateral earth pressures. Gravity earth retaining structures. Limit equilibrium	2×4=12

		method in Soil Mechanics. The Coulomb's wedge theory for lateral earth pressures.	
4	Stability of Slopes	The limit equilibrium method for calculating the factor of safety against slope failure. Planar and circular types of failure. Total and Effective stress analysis. Introduction to the method of slices.	2×4=12
5	Bearing Capacity of Soil	Limit equilibrium methods for the determination of the ultimate bearing capacity of a foundation: The slip circle method.	2×4=16
6	Flow of Water through Soil	Darcy's law of saturated flow. Determination of the coefficient of permeability (in the laboratory and in the field), the hydraulic gradient and critical hydraulic gradient. Flow nets and seepage quantities. The quicksand failure mechanism.	2×4=16
7	One Dimensional Consolidation	Soil behaviour for drained and undrained load conditions. Excess pore water pressure development and dissipation. Consolidation-induced settlements.	2×4=16

Learning Objectives

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

- Recognize how the behaviour in the micro-scale (at soil element level) affects the response in the macro-scale (boundary-value problem level);
- understand the significance of water flow through soil on the behaviour of soil and the response of Geotechnical systems and structures.

Operations Research & Optimization

Course Description

Basic principles of systems analysis. Linear programming, linear programming under multiple constraints, special topics on linear programming. Integer programming, topics on transportation, transit, placement, networks. Introduction to dynamic and non-linear programming, metahueristsic methods. Algorithms on optimization with MATLAB.

Semester: 5

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction to Operational Research	Introduction to Operational Research (OR). Concepts on optimization models, mathematical models, and decision-making problems. Engineering optimization problems.	1×3=3

#	Title	Description	Hours
2	Problem of Linear Programming	The problem of Linear Programming (LP). Graphic solution. Concepts on unique solution, infinite solutions, no solution and others.	1×3=3
3	SIMPLEX method	SIMPLEX method. Solution of maximization LP problem.	1×3=3
4	Problem of duality	Problem of duality. Solution of minimization LP problem. Big M method.	1×3=3
5	Transportation problem	Transportation problem (TP). Northwest square method. Lowest cost method.	1×3=3
6	Assignment problem. Integer Programming	Assignment problem. Integer programming (IP). Branch and Bound method.	1×3=3
7	Introduction to Nonlinear Programming	Introduction to Nonlinear Programming (NP). Introduction to Multicriteria Programming (MP).	1×3=3
8	MATLAB optimization Toolbox	Laboratory class: Presentation of MATLAB optimization toolbox. Solution of problems using the toolbox and MATLAB scripts.	1×3=3
9	Laboratory classes	Formulation and solution of LP and IP problems using computers.	4×3=12
10	Laboratory class: Revision	Laboratory class: Revision: formulation and solution of older exams.	1×3=3

Learning Objectives

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

- know the basic principles of operational research and systems' optimization, specifically for Civil Engineering problems;
- realize the value of computers to the solution of difficult problems in the area of applied mathematics, a branch of which is the operational research;
- understand the behaviour of special case algorithms;
- structure the formulation of LP and IP problems;
- compute either analytically by hand, or numerically by the optimization toolbox of MATLAB, the solution of LP and IP problems, both on the decision making level and on the design of civil engineering problems.

Laboratory on Water Resources and Environment

Course Description

Physical modelling of hydraulic works, port and coastal structures and wastewater pollution and water treatment works. The students will become familiarized with the areas of Hydraulics, Maritime and Coastal

Engineering, Water Resources Management and Environmental Engineering through laboratory scale experiments.

Semester: 5

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Theory	Safety rules and introduction to experimental modelling of hydraulics, coastal and environmental engineering works	5×3=15
2	Hydraulic experiments	Laboratory scale experimental modelling of hydraulic structures.	3×3=9
3	Hydroelectric unit	Laboratory scale experimental modelling of a Pelton wheel for electric energy production.	1×3=3
4	Environmental Engineering experiments	Laboratory scale experimental modelling of wastewater and water treatment plants.	2×3=6
5	Harbour works and coastal engineering experiments	Laboratory scale experimental modelling of marine hydraulics and coastal engineering works.	2×3=6

Learning Objectives

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

- get familiarized with processes and works that are related to Hydraulic, Coastal and Environmental Engineering;
- understand the application and use of physical modelling experiments to design hydraulic, harbour, coastal and environmental engineering works;
- know how to conduct experimental measurements and data analysis;
- measure the coastal waves and evaluate the effects of coastal structures, depth and seafloor on waves.

Structural Analysis of Statically Indeterminate Structures

Course Description

Structural analysis of statically indeterminate structures. Forces Method and Nodal Displacement Method. Influence Lines for indeterminate structures (Qualitative).

Semester: 5

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Force Method - Introduction	Difference between statically determinate and indeterminate structures. Equilibrium of Forces and compatibility of deformations. Static and kinematic duality. Static Indeterminacy. Formulation of the force method in systems of one-degree indeterminacy.	4
2	Solution of single and two DOF system	Applications to structures of one-degree indeterminacy selecting alternative redundants.	4
3	Calculation of deformations	Formulation of the Force method for multi-degree indeterminate structures. Evaluation of deformations in the primal – statically determinate system due to external load and flexibility coefficients by applying the unit load theorem. Reciprocity of Deformations, Betti-Maxwell Principle.	4
4	Temperature changes	Solving problems with two redundant forces. Criteria for selecting effective redundants. Solving problems accounting for temperature variations.	4
5	Support retreat - Elastic supports	Support settlements. Solution of relevant problems. Elastic supports. Applications. Qualitative sketch of moment and force diagrams.	4
6	Symmetrical structural systems	Symmetric structures about an axis. Symmetric and anti-symmetric loads. Symmetry Propositions for the whole or half of the structure. Solution of problems.	4
7	Selection of Statically Accepted Possible Status	Calculating the deformations of indeterminate structures. Unit Load Theorem using a statically admissible distribution of moments and forces. Compatibility checks of the solutions.	4
8	Introduction to the Nodal Displacements Method	Kinematic indeterminacy of structural systems. Nodal Displacements, degrees of freedom, DOFs. Neglecting axial deformations. Consideration of mixed fixation (fixed end and pinned –fixed beams). Formulation of the method of nodal displacements for single-DOF systems.	4
9	Dual consideration with Force Method	Formulation of the Nodal Displacements method of in multi-DOF systems. Dual consideration using the Forces Method.	4
10	Fundamental solutions	Fundamental solutions of fixed end beam and fixed – pinned beam, end displacements and rotations. Stiffness Coefficients. Examples.	4
11	Structural systems with oblique members	Structural systems with oblique members and geometrically coupled displacements. Investigation of appropriate equilibrium equations for the displacements. Examples. Symmetric loads.	4

#	Title	Description	Hours
12	Temperature changes. Resignations of supports. Elastic supports	Temperature variations. Support settlements. Elastic supports. Examples.	4
13	Qualitative scribing of M, Q, N forces diagrams & Influence lines	Qualitative sketch of moment and force diagrams. Simple and more complex indeterminate structural systems. Influence Lines of indeterminate structural systems. Muller-Breslau principle. Applications - Qualitative sketch of influence lines for reactions, moments and shearing and axial forces.	4

Learning Objectives

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

- know the basic principles of static and kinematic indeterminacy;
- realize the very basic concept of compatibility of deformations. Emphasis on the forces method is given in the equilibrium and the demand for the compatibility of deformations in the direction of the redundant quantities. Reversely, nodal displacements method relies on the compatibility of deformations and enforces equilibrium in the direction of the unknown displacements;
- understand the behaviour of relatively complex indeterminate structural systems;
- formulate the computational model of relatively complex indeterminate structural systems;
- analyse manually stress and strain state of indeterminate structural systems, qualitative sketching of M, Q, N forces diagrams and the influence lines of indeterminate structural systems.

Engineering Hydrology

Course Description

The aim of the course is to provide students with a general overview of the basic themes and issues in Engineering Hydrology, i.e., Precipitation, Losses, Watershed characteristics, Hydrographs, Hydrometry – Analysis and processing of hydrometric data, Rating curve, Unit Hydrographs, Flood hydrographs, Principles of statistical hydrology, IDF curves, Hydrological design.

Semester: 5

Teaching hours: 5

Course Units

#	Title	Description	Hours
1	Introduction	Introduction to the basic concept of the course (key definitions of Hydrology, Hydrography, Drainage, Hydrographic network, Hydrologic cycle, Water balance).	3

#	Title	Description	Hours
2	Precipitation	Natural processes, meteorological framework, precipitation types, measurement of precipitation, test of data homogeneity and analysis of double cumulative curves, completion of rainfall measurements: adaptation to different altitudes, surface integration of areal rainfall from point measurements	3
3	Evapotranspiration	Solar radiation in the atmosphere, evaporation measurement, Methods for the estimation of the evapotranspiration, The role of evapotranspiration in the Water balance.	3
4	Introduction to Hydrographs.	Watershed characteristics, Hydrographs, Base flow separation, Hydrological losses estimation.	6
5	Hydrometry	Discharge estimation using hydrometric data, flow measurement methods, river cross sections, Preparation and extension of a rating curve, Remarks on the rating curves, Flow estimation from measurements of water level meters/recorders,	3
6	Flood hydrographs – Routing – Sediment flow	Rainfall–runoff relationships: the UH, Basic assumptions of the UH, Determination of UH of a certain duration from known UH of a different duration: S-curve, Estimation of flood hydrograph using the UH, Synthetic UHs, Sediment flow estimation methods.	6
7	Groundwater	Introduction to Groundwater hydrology, types and characteristics of aquifers, groundwater management, groundwater salinization, test pumping.	3
8	Statistical Hydrology	Hydrology: Probabilistic approach, Basic statistics, Statistical distributions, Confidence levels, x2-Test, Kolmogorov-Smirnov Test, Design Risk: Estimation of volume based on acceptable risk,	6
9	Floods – Flood peaks estimation	IDF curves, Hydrologic design, Rational method for estimating flood peaks.	6

Learning Objectives

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

- fully understand hydrological processes (hydrological cycle components);
- estimate hydrological parameters;
- use statistics as a tool in hydrology;
- be involved in hydrologic design problems.

Hydraulics and Hydraulic Works

Course Description

Basic principles and computational methods of applied hydraulics (pressurized pipes, free surface conduits). Design of main hydraulic works and associated systems (aqueducts, pumps and their discharge pipes, water supply works, tanks, water distribution networks, channels, sewage networks, urban drainage works, flood protection works).

Semester: 5

Teaching hours: 5

Course Units

#	Title	Description	Hours
1	Introduction	Hydraulics and Hydraulic Works: definitions, historical evolution, importance.	5
2	Hydraulics of pressurized pipes	Boundary shear stress. Reynolds number. Laminar and turbulent flow. Hydraulic radius. Energy grade line. Hydraulic grade (piezometric) line. Calculation of friction energy losses. Equivalent roughness. Roughness coefficients. Commercial pipes.	5
3	Special issues of pressured flow	Converging and diverging flow. Local (minor) head losses. Hydrodynamic machinery.	3
4	Design principles for water transfer works	General layout of aqueducts. Layout in horizontal plan and vertical profile. Siphons. Problems of negative pressure. Typical cross sections.	3
5	Pumping stations and discharge pipes	Basic concepts (power and energy, hydraulic head, operation point, efficiency). Cavitation, water hammer. Technical and economical optimization of pumping systems.	3
6	Design principles of water supply works	Design and operation specifications of water supply works. Abstraction works from surface and groundwater resources. General layout of water transfer works, pumping stations, tanks, water distribution networks. Pipeline and channel materials.	3
7	Design flows of water supply works	Urban water uses. Demand and associated factors. Design population. Temporal distribution of water consumption. Typical peak coefficients per water use. Water losses. Emergency flows.	2
8	Tanks	Tank types. Hydraulic design. Inflow-outflow curves. Estimation of regulation capacity and emergency volume.	3

#	Title	Description	Hours
9	Water distribution networks	Typical diameters. Layout in horizontal plan. Pressure zones. Location of fire hydrants and specific devices (valves). Isolated zones. PRVs. Leakages.	3
10	Hydraulic analysis of water distribution networks	Network mode schematization. Estimation of output flows. Formulation of scenarios for normal and emergency operation. Numerical solving techniques. Pipeline sizing and associated constraints. Software applications.	4
11	Basic principles of free surface flow	Classification of free surface flow (steady – unsteady, uniform – non-uniform). Wave propagation velocity. Froude number. Specific energy. Specific power. Critical depth.	4
12	Uniform flow	Manning's formula. Calculations for prismatic channels. Composite cross-sections. Optimal cross-sections. Design principles for natural and constructed channels.	3
13	Critical depth and non-uniform flow	Subcritical and supercritical flow. Flow surface profiles. Hydraulic jump. Typical problems.	6
14	Sewer hydraulics	Flow conditions. Hydraulic calculations for steady uniform flow in circular conduits. Varying roughness coefficient.	4
15	Sewage works	General layout of sewage works. Combined and separate networks. Wastewater treatment plants.	2
16	Estimation of sewage flows	Design period, water consumption and sewer discharge, time-distribution of sewage flows, infiltration and inflows.	2
17	Design principles for sewer networks	Specifications and constraints. Velocity limits. Minimum slopes. Transitions. Local (minor) losses. Problems of large and small velocities.	4
18	Wastewater quality and technological issues of sewer networks	Composition of domestic sewage. Ventilation. Production of hydrogen sulphide and its quantification. Commercial pipes. Corrosion and anti-corrosion protection. Typical sewer shafts.	2
19	Urban floods and estimation of flood flows	General design principles. Urban and rural catchments. Return periods. Catchment delineation in urban environment. Rational method. Estimation of characteristic design quantities (time of concentration, critical rainfall intensity, runoff coefficient).	3
20	Design principles for urban drainage networks	Methodology of delineation and calculation of urban drainage networks in horizontal plan and vertical profile. Hydraulic controls. Construction and hydrological constraints.	3

Learning Objectives

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

- understand basic concepts and apply typical computational techniques of pressurized and open channel hydraulics;
- design typical water transfer works (pressurized pipes, pumping stations, channels);
- design typical water supply works (aqueducts, tanks, water distribution networks) and handle models of hydraulic analysis of water networks (using the free software EPANET);
- design sewer networks and drainage networks in urban environment;
- employ elementary technical-economical optimization at a preliminary design phase;
- recognizing essential elements for elaborating associated studies (technical report, general layout, pipe profiles);
- collaborate to solve composite design problems.

4.6 6th Semester

Foundations

Course Description

General principles of foundation design. Shallow foundations: Bearing capacity of foundations under central, eccentric and inclined loading. Principles of calculation of foundation settlement. Models of the soil reaction, contact pressures, settlements of foundations in cohesive and cohesionless soils, allowable deformations. Design of shallow foundations: spread and combined footings, strip foundations, mat foundations. Deep foundations: Construction considerations. Methods of deriving pile capacity for driven and bored piles in cohesive and cohesionless soils. Settlement of single piles. Axial capacity and settlement of piles in groups. Negative shaft friction, lateral loading of piles. Principles of the foundation design based on Eurocode EC-7.

Semester: 6

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Principles of foundations	Foundation types. Contact stresses at the foundation base and linear distribution.	1×4=4
2	Bearing capacity of surface foundations.	Vertical axial and eccentric loading. Limit analysis methods.	2×4=8

#	Title	Description	Hours
3	Calculation of settlements in surface foundations.	Calculation using elastic formulae. Settlement analysis in clays and sands. Settlements of beam foundations. Modulus of subgrade reaction.	4×3=12
4	Pile foundations	Axial capacity of single piles using analytical methods and pile load tests. Settlement of single piles and pile groups.	4×4=16
5	Horizontal loading of piles. Analysis of foundations using Eurocode 7.	Partial factors and analysis methods for surface foundations and piles.	

Learning Objectives

Analysis of the bearing capacity and settlements of different types of surface and pile foundations.

Road Construction

Course Description

Introduction to the procedures for the quantification and cost estimation of construction and roadside equipment, with emphasis on the detailed determination of unit quantities. Basic principles of road construction and materials. Basic principles of analysis and distress.

Semester: 6

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Road distress due to traffic	Factors affecting loading of road structures, basic analysis principles and theories, comprehension exercises in class.	2×4=8
2	Cross-sections	Lateral formations, slope construction - grading, area measurement.	1×4=4
3	Areas – volumes – earthworks	Diagram of areas, shrinkage factor, table of earthworks, volume estimation, Bruckner diagram, relation between vertical alignment, diagram of areas and Bruckner diagram, average haul distance.	2×4=8
4	Tunnel construction	Particularities, types, cross sections (necessity of EL- lane guidance, vertical clearance), escape routes, equipment.	1×4=4
5	Costing of road works	Bill of quantities-budget for road projects (tasks completed by the road engineer, but also approximate estimation of the remaining ones).	1×4=4

#	Title	Description	Hours
6	Structural road cross-sections	Road cross-section elements, pavement types and operation, basic phases of a road construction project, Specifications.	2×4=8
7	Material characteristics of road design and construction	Basic material characteristics that are useful for design. Soil types and soil classification, importance of laboratory, comprehension exercises in class.	2×4=8
8	Construction issues of road projects	Project Principles, content of Tender Documents, Delivery.	2×4=8

Learning Objectives

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

- perceive the inter-scientific character of road works;
- understand the number and content of the bill of quantities to be taken into account in the costing of road projects;
- precisely define the details of unit quantities;
- cost road projects (tasks completed by the road engineer, as well as approximate estimation of the remaining ones);
- know basic road cross-sections and related specifications;
- comprehend general principles of road design, analysis and distress;
- know general road construction materials.

Matrix Structural Analysis - 1D Finite Elements

Course Description

The Direct Stiffness Method in plane truss, plane frame, spatial truss, spatial frame. Rigid Offsets. Internal Releases. Beams of variable cross section. 1D Finite Elements.

Semester: 6

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Overview of matrix structural analysis and design. Primary structural members and their modelling – Matrix structural analysis steps. Flexibility – stiffness methods. Computer programs and rational use. Basic steps of programming the direct stiffness method. Degrees of freedom of plane and spatial structures.	2

#	Title	Description	Hours
2	Plane truss	Global and local systems of axes. Vectors of end-actions and end-translations of a plane truss element. Transformation matrix. Calculation of local-global stiffness matrix of a plane truss element: analytical and numerical (shape function, deformation matrix) methods. Vectors of nodal-forces and nodal-translations, global stiffness matrix of a plane truss. Modification of global stiffness matrix due to support conditions – Reordering matrix. Modification of global stiffness matrix of a plane truss due to inclined and elastic supports. Plane truss subjected to member loading. Restrained – equivalent structure. Stress resultants of plane truss members.	12
3	Plane frame	Vectors of end-actions and end-displacements of a plane frame element. Transformation matrix. Calculation of local - global stiffness matrix of a plane frame element: analytical and numerical (shape functions, deformation matrix) methods. Vectors of nodal-forces and nodal-displacements, global stiffness matrix of a plane frame. Modification of global stiffness matrix due to support conditions – Reordering matrix. Modification of global stiffness matrix of a plane frame due to inclined and elastic supports. Plane frame subjected to member loading. Restrained – equivalent structure. Stress resultants of plane frame members.	10
4	Spatial truss	Transformation matrix of a spatial truss element. Local - global stiffness matrices of a spatial truss element: analytical and numerical methods. Steps of analysis of a spatial truss.	4
5	Spatial frame	Transformation matrix of a spatial frame element. Basic transformation matrix. Transformation matrix with special orientation. Transformation matrix for special auxiliary point. Formulation of transformation matrices of elements of other type of skeletal structures. Local stiffness matrix of a spatial frame element. Formulation, stiffness terms. Formulation of local stiffness matrices of members of all other types of skeletal structures. Vectors of nodal-actions and nodal-displacement of a spatial frame.	4
6	Grid	Analysis of a grid structure. Solving a grid structure as a special case of a spatial framed structure.	4
7	Rigid joints	Kinematic relations and equivalent actions between two points of a rigid body plane. Rigid joints in plane framed structure. Kinematic relations and equivalent actions between two points of space rigid structure. Rigid joints in space frame element.	8
8	Internal releases	Combined node method. Degrees of freedom of combined nodes. Assembly of total global stiffness matrix with combined nodes. Computation of nodal actions of restrained and equivalent structures with combined nodes. Elastic hinge. Internal releases– Method of modified stiffness matrices. Modified matrices and internal releases. Restrained actions – Equivalent actions. Static condensation method. Physical interpretation of static condensation.	8

#	Title	Description	Hours
		Qualitative examination of the stiffness coefficients of a hyper-element. Stiffness matrix and restrained actions with elastic hinge	
9	Elements of variable cross-section	Stiffness matrix– Analytic evaluation and approximate computation. Restrained actions. Analytic evaluation and approximate computation.	4

Learning Objectives

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

- know through matrix view, the method of nodal displacement;
- they are aware of the analysis of structures and of the developing intensive actions;
- understanding the necessary theoretical background for writing a software code to solve skeletal structures.

Reinforced Concrete I

Course Description

Introduction. Design limit states. Ultimate and serviceability limit states. Design against axial actions: Assumptions, properties of materials. Rectangular sections. Axial tension. Prevalent bending, diagrams and CEB design tables. Prevalent compression. Columns, interaction diagrams. T-beams, analytical design and design tables. Anchorage of steel bars, bond, anchorage types, basic development length. Lap splices. Design for shear. Cyclic shear. Capacity design of beams in shear. Ductility. Capacity design of columns for bending and for shear. Torsion. Cracking. Modelling of RC structures. Construction detailing, minimum covers, distance of bars, allowed curvatures. Minimum requirements per structural element (sectional dimensions, minimum reinforcement). Laboratory tests (production-reinforcing-casting of concrete, anchorages).

Semester: 6

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Definitions. Physical and mechanical properties of materials (concrete and steel). Design values and partial safety factors	1×4=4
2	Concrete composition, durability, cover	Concrete materials, composition, properties. Durability. Steel corrosion. Concrete cover	1×4=4
3	Limit states	Ultimate and serviceability limit states. Loads and design actions. Combination of actions. Partial safety factors.	1×4=4

#	Title	Description	Hours
4	Bending with and without axial force	Bending with and without axial force. Assumptions. Rectangular sections. Single reinforcement	1×4=4
5	Bending with and without axial force	Bending with and without axial force (cont). Double reinforcement	1×4=4
6	T-beams	Slab contribution to the effective with of flanges. Analysis of T-beams in bending. Thin-webbed T-beams	1×4=4
7	Slabs	Analysis of one- and two-way slabs. Slab depth vs deflections. Design and detailing	2×4=8
8	Columns	Interaction diagrams (bending and axial force). Detailing	1×4=4
9	Shear	Shear in RC elements. Members not requiring design shear reinforcement. Maximum shear force limited by crushing of the compression struts and by yielding of shear reinforcement. Detailing	2×3=6
10	Anchorages and laps	Local bond vs local slippage. Design anchorage length, influencing factors. Laps and mechanical couplers.	2×3=6
11	Torsion	Analysis, direct and indirect torsion. Members not requiring design for torsional reinforcement. Maximum torsion moment limited by crushing of the compression struts and by yielding of shear and longitudinal reinforcement. Detailing	1×4=4

Learning Objectives

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

- know the basic material properties of reinforced concrete;
- know the basic theory of reinforced concrete;
- be able to understand the code requirements and the physical meaning of design models;
- be able to design a simple reinforced concrete structure (dimensioning, detailing, designing drawings) under normal actions.

Steel Structures I

Course Description

Aim of this course is to provide students with the necessary knowledge for addressing ordinary steel structures, by enabling them to understand the behaviour of such structures and check / dimension their primary members and connections in accordance with fundamental principles of mechanics as well as specifications of current codes.

Semester: 6

Teaching hours: 5

Course Units

#	Title	Description	Hours
1	Introduction	Course objectives and administrative issues, work phases of structural engineers in steel structures design and construction, types of structural steel projects, production methods of structural steel, hot-rolling, standard sections, shapes of cross-sections, tables of standard sections, cold-forming, thin-walled sections, steel sheeting, built-up sections, stages of production of steel structures, fabrication, erection, mechanical properties of steel, steel grades, comparison between construction materials, advantages and disadvantages of structural steel, the role of design codes, on Eurocodes and Eurocode 3, ultimate and serviceability limit states, actions and resistances, load and material partial factors, loads, load combinations.	1×5=5
2	Members in tension	Examples of tension members from practice, mechanical behaviour, yielding strength of gross section, ultimate strength of net section, overall tension resistance according to EC3, ductility criterion, staggered bolt holes, critical net section, eccentrically connected members. Application examples.	1×5=5
3	Simple bolted and welded connections	Examples of steel connections from practice, general discussion on steel connections, advantages and disadvantages of bolted versus welded connections, selection of appropriate connection type depend on the location and the available options of transportation and erection, bolting geometry, bolt grades, bolt distance limitations, mechanical behaviour of simple bolts in shear, bolt shear strength, bearing strength, shear planes, bolts in tension, bolts in combined shear and tension, EC3 specifications, long bolted connections, ductility criterion, welding technology, types of welds (fillet and butt welds, full versus partial penetration, welding faults, quality control, welding strength, EC3 specifications, long welded connections. Application examples.	1×5=5
4	Members in compression	Examples of compression members from practice, mechanical behaviour, potential failure modes (yielding, flexural buckling, local buckling), equilibrium equations in deformed configuration, differential equation of flexural buckling, critical buckling loads, buckling modes, lateral restraints, interaction between buckling and yielding, influence of initial imperfections, buckling curves, compression resistance according to EC3, flexural buckling about weak and strong axis, local buckling, cross-section classification for compression, influence of boundary conditions,	2×5=10

#	Title	Description	Hours
		equivalent buckling length, buckling of frame columns. Application examples.	
5	Laterally restrained members in bending	Examples of members in bending from practice, mechanical behaviour, bending and shear, moment of inertia, moment of area, shear area, advantageous cross-section shapes and orientation, elastic verification, interaction of bending and shear, equivalent von Mises stresses, serviceability verification, elastoplastic behaviour of cross-section in bending, plastic verification, EC3 specifications, local buckling and cross-section classification for bending. Application examples.	2×5=10
6	Torsion and warping	Examples of members in torsion from practice, shear centre of different cross-sections, ways to resist torsion, mechanical behaviour of bar with solid circular cross-section in torsion, torsional constant, behaviour of hollow sections, pure or St. Venant torsion, behaviour of open sections, warping, stresses due to warping, differential equation of torsion and warping, EC3 specifications. Application examples.	1×5=5
7	Laterally unrestrained members in bending	Concept and mechanism of lateral-torsional buckling, behaviour of closed and open sections, differential equation of lateral-torsional buckling, elastic critical lateral-torsional buckling moment, influence of bending moment diagram, location of load application over the cross-section and boundary conditions, EC3 specifications, lateral restraints. Application examples.	1×5=5
8	Sections under combined action effects	Examples from practice, stresses due to each action effect, equivalent stress and elastic verification, plastic interaction between axial force, shear forces and bending moments for different cross-section shapes, interaction diagrams, EC3 specifications. Application examples.	1×5=5
9	Members under combined action effects	Examples from practice, possible failure mechanisms of members under combined axial force and bending moments (yielding, flexural buckling about weak/strong axis, local buckling, lateral-torsional buckling), nonlinear interaction between combined axial force and bending moment, differential equation of equilibrium, coefficient of elastic interaction, EC3 specifications. Application examples.	1×5=5
10	Structural layout of typical single-story industrial steel buildings	Examples from practice, geometrical considerations, main structural members (main frames, bracing systems, purlins, head-beams, frontal columns) and their structural function, load resisting mechanisms, common cross-sections and their orientation, typical connections. Application examples.	1×5=5

Learning Objectives

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

- understand the mechanical behaviour of beam-type steel members and their connections;
- identify their possible failure mechanisms;
- check their adequacy and dimension them according to Eurocode 3;
- comprehend the structural system of simple steel structures (single-story industrial buildings, pedestrian bridges).

Transportation Systems Planning

Course Description

Introduction to the basic components of the Transport Planning approach. Helps students to understand the necessity of a systemic analysis in Transport Planning and the capability of transport modelling as modelling tool. Transportation demand models (forecasting future needs for infrastructure and modes) are presented. Introduction to the basic four step planning process. Computational algorithms and real case examples are presented.

Semester: 6

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction To Transport Systems	Characteristics of the transport system. Interaction between land use and transport systems.	1×3=3
2	The Urban Transport System	The Urban Transit System, main features, standards, level of service, passenger comfort and safety.	1×3=3
3	The Planning Process. O-D Surveys	The necessity of a systemic planning approach. Land use. Models and steps for forecasting future demand. Inventory, O-D surveys, area of study, zoning, sampling and sample size, questionnaires. Athens O-D surveys.	2×3=6
4	The Planning Process-Trip Generation	The four-step planning methodology. Trip Generation: Cross-Classification (Category Analysis), Regression Analysis.	2×3=6
5	The Planning Process-Trip Distribution	The four-step planning methodology. Trip Distribution: Growth Factor models (uniform factor, average factor, Furness, Fratar, Detroit), Gravity Models.	2×3=6

#	Title	Description	Hours
6	Supply And Demand Analysis	Introduction to the basic elements of supply and demand models. Economic aspects. Transportation infrastructure supply analysis: cost models and economic planning. Demand-supply and network equilibria.	1×3=3
7	The Planning Process-Modal Split	The four-step planning approach. Modal split: Aggregate choice models - trip end models-diversion curves. Discrete choice models (logit models).	2×3=6
8	The Planning Process-Network Assignment	The four-step planning approach. Network assignment: Static models (deterministic/stochastic) -minimum path algorithms, all-or-nothing assignment (no/with capacity constraints). Dynamic models.	2×3=6
9	The Example Of Athens Transit System	Implementation of the four-step planning approach in the case of the Athens transit system.	1×3=3

Learning Objectives

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

- familiarise themselves with the transport demand forecasting models;
- understand the necessity for the systemic approach in transport planning;
- understand the applicability and limits of modelling tools for transport demand forecasting;
- familiarise themselves with the use of simple models in real cases using Excel.

4.7 7th Semester

Earthquake Engineering

Course Description

The course provides the fundamental principles of earthquake engineering and seismic design.

Semester: 7

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction, Critical flow theory	The Single-Degree-of-Freedom (SDOF) oscillator - the equation of motion - free vibrations - harmonic vibrations	1×4=4
2	Elastic response spectrum	The elastic response spectrum, Alternative forms for representing the response spectrum, effective acceleration and velocity. Code (EC8)	4×3=12

#	Title	Description	Hours
		design spectrum: ground acceleration, importance, effect of soil conditions.	
3	Inelastic behaviour and design against seismic loading	Inelastic behaviour of Single-Degree-of-Freedom (SDOF) oscillators - The capacity curve - Idealisation/bilinearization of the capacity curve - Definition of the behaviour factor and of the ductility - Recommended q values in EC8 - ductility class DCM/DCH - ductility demand and capacity - Predictive relationships q-μ-T - Seismic design philosophy & methodology- Constant ductility spectra - Global and member ductility capacity and demand.	4×4=16
4	Multi-degree of freedom systems	Introduction to MDOF structures, Eigenmodes, Modal response - Modal response of plane frames and of a single storey building, Modal response spectrum analysis, Rules for combining modal response (SRSS, CQC) - The lateral force method of analysis.	4×4=16

Learning Objectives

- The fundamentals of seismic design and earthquake engineering.
- The major provisions of Eurocode 8 and how the fundamentals of earthquake engineering are implemented in the code.
- The concept of seismic design for nonlinear/inelastic structural behaviour.
- The application of the modal response spectrum analysis method for seismic design.

Construction Management

Course Description

The course deals with the regulatory framework and standards of project management as well as with the necessary procedures for the time and cost planning of technical projects. Thus, the course is based on modern standards (mainly ISO 21500 and PM2) and the methods, techniques, procedures and skills required to complete a project (mainly technical) at the planned time and within budget.

Semester: 7

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduction to construction project management. Life cycle of technical projects & Project management. Regulatory framework. Related Standards. Managing human resources. Related competences. Organization for the execution of projects. Complexity in the	3×3=9

#	Title	Description	Hours
		implementation of projects. Work Breakdown Structure (WBS), Organizational Breakdown Structures (OBS). Codification for project & construction management.	
2	Time Scheduling & Cost planning	Project Planning & Controlling- Graphical Methods (Progress Curves (S-Curves), Planning Matrices, Horse Blankets), Lines of Balance, RSM. Network Analysis (CPM, MPM, PERT, GERT), Time Floats. Resource planning - Levelling with time / resource constraints. Project Costs - Fundamentals of pricing and costing of engineering projects - Price analyses, The cost-time trade-off. Time/Cost acceleration. Project Control & Earned Value Analysis.	8×3=24
3	Recapitulation	Recapitulation & resolving questions	3×3=9

Learning Objectives

[Missing information in the English transcript]

Dynamics of Structures

Course Description

Formulation and solution of equation of motion of one-degree of freedom systems for any external load. Systems of many degrees of freedom of motion. Free and forced vibrations of multi-degree-of-freedom systems. Damped of multi-degree-of-freedom systems. Dynamic analysis of multi-story building.

Semester: 7

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Introduction. Differences in static, dynamic behaviour of structures. Dynamic loads. Dynamic equilibrium. Degrees of freedom of a structure. Dynamic model and equation of motion. Formulation of equation of motion of one-degree of freedom with the method of direct equilibrium and with the principle of virtual work.	1×4=4
2	Study of single-degree-of-freedom systems vibrations	Systems with one degree of freedom of motion. Free undamped and damped vibrations of single-degree-of-freedom systems. Forced vibrations of single-degree-of-freedom systems. Study of forced undamped and damped vibrations of single-degree-of-freedom systems subjected to harmonic and periodic forces. Resonance. Forced undamped and damped vibrations for any external load. Duhamel integral. Calculation of the	3×4=12

#	Title	Description	Hours
		Duhamel integral. Applications of the Duhamel integral. Response to step and harmonic loads. Study of forced vibrations of single-degree-of-freedom systems subject to ground motion. Response spectra. Influence of gravity on forced vibrations of single-degree-of-freedom system.	
3	Numerical calculation of dynamic response	Numerical calculation of dynamic response. Central Difference Method. Acceleration Method (Newmark). Numerical calculation of the Duhamel integral. Demonstration of the dynamic behaviour of a single-degree-of-freedom system on PC.	1×4=4
4	Generalized single-degree-of-freedom systems	Generalized single-degree-of-freedom systems. Shape functions. Calculation of elastic, kinetic energy, virtual work of non-conservative forces.	1×4=4
5	Formulation of equation of motion of multi-degree-of-freedom systems	Systems with many degrees of freedom of motion. Elastic, inertial and damping forces of a structure. Formulation of stiffness matrix element with constant cross section. Formulation of stiffness matrix of a structure. Formulation of mass matrix of multi-degree-of-freedom systems with lumped and distributed mass. Geometric stiffness matrix structure. Formulation of stiffness matrix element with variable cross section. Static condensation of degrees-of-freedom.	2×4=8
6	Dynamic analysis of singe- and multi-story buildings	Dynamic analysis of multi-story buildings. Eccentricity matrix. Transformation matrix. Stiffness matrix of a building. Mass matrix of a building.	1×4=4
7	Dynamic analysis of multi-degree-of-freedom systems	Free vibration of multi-degree-of-freedom systems. Frequency equation of multi-degree-of-freedom systems. Eigenvalues, mode shapes, natural mode shapes of vibration of multi-degree-of-freedom systems. Orthogonality conditions of modes shapes. Properties of the eigenfrequencies and modes shapes of free undamped of multi-degree-of-freedom systems. Forced vibrations of undamped of multi-degree-of-freedom systems. Generalized mass, stiffness, external force of multi-degree-of-freedom systems. Damped of multi-degree-of-freedom systems. Uncoupled damped equations of motion. Evaluation of damping matrix of multi-degree-of-freedom systems. Dynamic response of damped multi-degree-of-freedom systems.	3×4=12
8	Participation of the modes shape in the mode superposition method	Participation of the modes shapes in the mode superposition method. Modal contribution. Modal contribution factor. Truncation error of higher modes. Base shear, Overturn moment of multi-degree-of-freedom building.	1×4=4

Learning Objectives

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

- study the dynamic behaviour of single and multi-degree-of-freedom systems;
- form the motion equations governing the behaviour of these structures;
- solve equations of motion with analytical and / or modern computational methods.

Laboratory on Humanities

Course Description

The course deals with the interface of civil engineering issues with humanities and social sciences, such as history and philosophy of technology, political influences, environmental and professional ethics, and technical communication.

Semester: 7

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Co-evolution of technology, science and philosophy in world history	Evolution of construction of technical works, in connection with the formulation of scientific theories, from antiquity to the present day. Relationship of engineering projects and theories with location (geographic, cultural and social characteristics). Philosophical dimension (ethics, logic, metaphysics, aesthetics) of technological and scientific actions.	2×3=6
2	Historical and philosophical introduction to the scientific method	Ancient Greek philosophy and physics. Modern scientific revolution. Basic scientific assumptions, inference and drawing conclusions; falsifiability, deduction and induction. Probability and inductive logic, Bayesian reasoning. Making decisions on complex issues.	2×3=6
3	Politics and technology	Evolution of the relationship between politics and technology. Globalized economic competition (how it is determined by political action to exploit resources and rationalize their management using technology, but also to seek and adopt new technologies). Relationship between politics and major infrastructure projects (how the subways, highways, major hydraulic projects, etc., are major political choices that determine development). Politics and state-of-the-art technologies (how information technology, Internet, biotechnology, etc., influence developments, while social media, manipulated or not, are more effectively involved in triggering social reflexes).	2×3=6

#	Title	Description	Hours
4	Natural and built environment	Natural, built and social environment in the light of philosophical thought. Diachronic philosophical approaches: ecosystems issues in a natural, technological, social, economic, political, and aesthetic environment.	2×3=6
5	Engineering ethics	Engineering codes of conduct; guidance framework for decision-making using common ethical reasoning tests; combined technical-ethical analysis in case studies.	2×3=6
6	Technical writing and professional communication	Organizing a technical report (Title, Contents, Tables, Figures, Summary, Conclusions), striving for clarity and simplicity, conforming to or developing a style, avoiding common mistakes.	2×3=6

Learning Objectives

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

- recognize the life cycle of projects and scientific theories that have worked for long periods of time, in order to gain experience and appreciate the impact of their work on the philosophical (moral, aesthetic) perception of citizens;
- recognize the contribution of the scientific method to the production of new knowledge and technology, and identify irrational beliefs even if they are established;
- hone in on value content and ethical theories about the natural and built environment, and the importance of environmental policies;
- recognize the non-technical dimensions of major infrastructure projects, identify potential political and social implications of their support, acknowledge the importance of informing the population and democratic decision-making, and assess alternatives to deal with a potential impasse;
- identify problematic ethical aspects of civil engineering case studies and evaluate technical decisions by applying common ethical reasoning tests;
- apply writing techniques that guide the reader and facilitate the comprehension of a technical document.

Computer Lab - Analysis and Design of Structures

Course Description

The aim of the course is to familiarize the students in a comprehensive manner to the topic of applied structural analysis and design using computational means.

Semester: 7

Teaching hours: 3

Hours Course Units

#	Title	Description	Hours
1	Laboratory of Structural Analysis and Antiseismic Research	Finite elements and degrees of freedom. Numerical behaviour of line and area finite elements (FE). Local axes and sign of internal forces and stresses. Basic structure of a FE computer analysis code. Line beam-column models with eccentricity of horizontal and vertical members using three-dimensional rigid offsets. Modelling of shear walls using beam-column elements with rigid offsets and models of multi storey coupled shear walls with equivalent frames.	1×3=3
2	Laboratory of Structural Analysis and Antiseismic Research	Modelling of diaphragms. Models of open section shear wall cores using beam-column elements. Models accounting for shear and torsional section deformations. Significance of the location of cores in plan.	1×3=3
3	Laboratory of Structural Analysis and Antiseismic Research	Envelopes of internal forces and deformations under different support conditions in multi storey buildings with or without a basement. Relative rigidities of beams and columns.	1×3=3
4	Laboratory of Reinforced Concrete	Models of reinforced concrete (RC) members and structures. Linear and nonlinear analysis methods following EC2. Cracking, yielding, failure. Step by step section analysis to failure. Resistance and stiffness interaction with axial load.	1×3=3
5	Laboratory of Reinforced Concrete	Simple models for preliminary design and sizing, for use inn SLS and ULS limit states. Beams (T beams, variable section beams, prestressed beams), equivalent frames for flat slab frame analysis, axially loaded elements with 2nd order effects.	1×3=3
6	Laboratory of Reinforced Concrete	Modelling of large lightly reinforced concrete walls. Modelling of foundations (footings, mat foundation, piles).	1×3=3
7	Laboratory of Reinforced Concrete	Design using the Strut and Tie model. Applications in the design of a deep beam and a multistorey wall with openings.	1×3=3
8	Laboratory of Steel Structures	Simple models of steel structures. FE types for modelling of different members, mesh density, section orientation. Buckling length and second order effect sensitivity. Modelling of connections and eccentricities.	1×3=3
9	Laboratory of Steel Structures	Modelling of the compression braces in steel structures. Lateral bracing. Lateral and local buckling. Modelling of bridge cranes. Modelling of composite structures with steel beams and concrete slabs.	1×3=3

#	Title	Description	Hours
10	Laboratory of Steel Structures	Interrelation of the method of modelling, the method of analysis and the design checks of steel structures. Application examples.	1×3=3
11	Laboratory of Earthquake Engineering	Modal building analyses: modelling for the establishment of symmetric and antisymmetric mode shapes. Examples of structural models using line and area FE. Modelling of stiffness, inertia and damping.	1×3=3
12	Laboratory of Earthquake Engineering	Development of models suitable for seismic loading analysis. Methods based on dynamic analysis: uses, differences, advantages and disadvantages. Application examples for structures modelled using line, area and three-dimensional FE and combinations of these.	1×3=3
13	Laboratory of Earthquake Engineering	Flexible and rigid diaphragm models for seismic actions. Soil structure modelling.	1×3=3

Learning Objectives

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

- develop a numerical model of the structure;
- select specific member requirements depending on the structural material and the mechanical response, in accordance with the design requirements;
- be able to evaluate the reliability of the model and perform more specific detailed model refinements.

Maritime Hydraulics and Harbour Engineering

Course Description

Introduction to sea hydraulics. Waves: generation of wind-waves, wave measurements, real waves and their mathematical representation. Theories of small and finite amplitude waves. Analysis of wave records: description parameters, distribution of wave heights. Seabed influence: shoaling, breaking, refraction. Wall influence: reflection, diffraction. Pressures of standing and breaking wave on vertical wall. Types and roles of ports. Design criteria for harbour works. Vessel characteristics. General layout of harbours. Navigation channels, port entrance, manoeuvring area. Wharves and piers. Design of rubble-mound breakwaters. Walls with vertical face: calculations understanding and breaking wave conditions. Design of quaywalls. Berth outfits. Planning of back – up area of general cargo area. Sheds and other facilities.

Semester: 7

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduce students to the subject area of the course.	0.5×4=2
2	Mathematical Wave Theories	Airy and non-linear (Stokes) waves. Effect of the sea bottom on the characteristics of simple harmonic waves.	1.5×4=6
3	Real waves	Introduction to spectra. Short-term - Long-term wave distribution.	1×4=4
4	Waves in coastal zone	Description of wave mechanisms of shoaling, refraction, reflection, diffraction and wave breaking. Exercises are solved.	3×4=12
5	General port layout	Design wave parameters	1×4=4
6	"External" and ''Internal'' Harbour Works	Design of projects with slopes, design of projects with vertical front, configuration of berth - mooring works, Gravity walls - Failure Mechanisms. Estimation of actions from environmental and functional loads - tests of adequacy of gravity constructions. Environmental impacts from harbour works.	6×4=24

Learning Objectives

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

- understand the basic principles of maritime hydraulics (e.g. linear wave theory, waves formation in coastal zone) through detailed mathematical formulas and diagrams;
- understand the basic principles of port design through: (i) analytical wave prediction models; and (ii) hydrodynamic loading calculations on vertical fronts and armour slope stability;
- assess the impact of wave reflection, diffraction and breaking phenomena on both the wave disturbance and the effects on the fronts;
- design and size at a preliminary stage breakwaters with inclined slopes and with a vertical front through equations;
- design and size at a preliminary stage gravity quay walls;
- estimate basic port design parameters (harbour depth, entrance width, required lengths of boat mooring etc.).

Traffic Flow

Course Description

Traffic Flow is part of 7th semester courses. It is compulsory for the students at the Transportation Planning and Engineering cycle. The course includes basic definitions of traffic flow, traffic capacity and level of service of a single road as well as statistical analysis distributions and sampling regarding traffic counts. It also includes traffic counts by the students and analysis of saturation effect. The course foresees four hours of theory and exercises every week. During the exercises practical examples of applications are developed and in general the overall understanding of the course is assisted. It should be noted that there is no clear distinction between theory and exercises, since the theory relies on exercises and exercises deal with questions about the theory. Students consist of one class.

Semester: 7

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Basic traffic flow definitions	Definitions and characteristics of traffic flow parameters Variability of traffic density Traffic composition and traffic density diagrams Fundamental traffic flow equations and fundamental diagrams Macroscopic traffic flow concepts	3×4=12
2	Adjustment of statistical distributions	Statistical distributions of arrivals Statistical distributions of time headways Advanced statistical analysis distributions Goodness of fit parameters of statistical distributions	3×4=12
3	Estimation of traffic capacity and level of service	Traffic capacity and level of service Estimation of traffic capacity and level of service of interurban roads of four or more lanes Estimation of traffic capacity and level of service on selected road sections of freeways Estimation of traffic capacity and level of service on interurban roads of two lanes in total	4×4=16
4	Traffic counts	Methods and principles of traffic counts Moving observer method Basic sampling principles	3×4=12

Learning Objectives

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

- learn the basic definitions and parameters of uninterrupted traffic flow;
- realise the concept of traffic and the way of calculating traffic parameters;
- understand the importance of analytical and statistical approaches on traffic flow at uninterrupted flow conditions;
- develop basic macroscopic traffic statistical models;
- estimate through statistical models traffic capacity and level of service of a road section at uninterrupted flow conditions.

Reinforced Concrete II

Course Description

Slabs. Two-way slabs. Flat slabs. Non rectangular slabs. Frames. Footings. Corbels. Deep beams. Walls. Buckling, Seismic design. Repair and strengthening of reinforced concrete structures. Surveillance and certification of production control.

Semester: 7

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Slabs	Ribbed (joist) and waffle slabs. Slabs with concentrated loads	8
2	Punching	Flat slabs. Failure mode. Models, analysis and design	8
3	Footings	Isolated footings, strip footings, mat foundation. Analysis models, design and detailing	8
4	Joints	Joints behaviour, design and detailing	4
5	2nd order effects	Buckling of columns under axial force and bending moment. Analysis and design	8
6	Cracking	Cracking theory, tension stiffening effect. Crack width calculation. Crack control.	4
7	Seismic design	Earthquake action on concrete structures. Requirements, capacity design.	4
8	Ductility	Section, member and frame ductility. Regularity. Behaviour factor.	4
9	Confinement	Necessity for confinement and means of achievement. Mechanical and design models.	4

Learning Objectives

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

- understand the behaviour of concrete structures under ultimate and serviceability limit states;
- design concrete structures and draw construction drawings;
- know elements of seismic behaviour of reinforced concrete structures.

Experimental Soil Mechanics

Course Description

The course covers laboratory methods commonly used to determine the soil parameters that govern its engineering behaviour. As part of the course the students have the opportunity of performing standard laboratory tests using the facilities housed within the Soil Mechanics Laboratory.

Semester: 7

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Experimental determination of soil properties required for the design and analysis of soil structures, such as retaining walls, slopes, earthdams and foundations. Standard procedures for soil testing. Laboratory soil testing: 1) Soil classification tests. 2) Measurement of elementary soil properties including density, water content, void ratio, specific gravity, etc. 3) Atterberg limit tests. 4) Grain size analysis including sieve and sedimentation analysis.	2×4=4
2	Steady state groundwater flow	Steady state groundwater flow: one dimensional flow, hydraulic conductivity, critical hydraulic gradient, two dimensional flow and flow nets. Laboratory soil testing: Measurement of the permeability coefficient of soils	2×4=12
3	Theory of consolidation	Properties of fine-grained soils for calculating the amplitude and rate of settlement of structures. Field measurement of pore water pressure piezometers. Laboratory soil testing: Consolidation test – determination of compressibility, overconsolidation ratio and preconsolidation stress, consolidation coefficients. Assessment and quantification of fundamental parameters controlling consolidation settlement calculations: Es, cc, cs, cv.	2×4=12
4	Loading stress paths. Shear strength of sands	Initial stress conditions and loading stress paths resulting due to stress changes in geotechnical applications as well as in the laboratory. Shear strength and dilatancy of sand. Laboratory soil testing: Direct shear test: measurement of shear strength parameters on a predetermined surface of rupture for loose and dense sand.	2×4=12
5	Shear strength of cohesive soils	Shear strength of normally and overconsolidated clays – Critical State Theory. Laboratory soil testing: Test method for unconsolidated-undrained and consolidated-undrained triaxial compression tests on cohesive soils (UU and CU tests)	3×4=16

#	Title	Description	Hours
6	Measurement of soil stiffness. Applications.	The use of experimentally defined strength and deformation soil properties in practical applications. Laboratoty soil testing: 1) Measurement of limiting earth pressures in a retaining wall model. 2) Proctor test: compaction test used to determine the relation between water content and dry unit weight and to find maximum dry unit weight and optimum water content.	2×4=16

Learning Objectives

The students use the facilities of the teaching soil mechanics laboratory to perform tests simulating the loading conditions in geotechnical applications. By the end of the course the students will possess the skills and knowledge necessary to determine the soil parameters required for the analysis and design of soil structures such as retaining walls, slopes, earthdams and foundations.

Steel Structures II

Course Description

Aim of this course is to provide students with the necessary additional knowledge for independently addressing ordinary steel structures, by enabling them to properly perform the conceptual structural design for resisting static and seismic actions, check / dimension the members and connections in accordance with fundamental principles of mechanics as well as specifications of current codes, and confront more specialized issues, such as fatigue, corrosion resistance and fire protection.

Semester: 7

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Connections	Prestressed bolts, shear transfer mechanism, slip resistance, surface categories, bolt hole types, slip-resistant bolts in the serviceability or the ultimate limit-state, prestressed bolts under shear and tension, loss of prestress, pins (geometry, failure mechanisms, verifications), hollow section joints (geometry, failure mechanisms, verifications), EC3 provisions. Application examples.	2×4=8
2	Moment frame joints	Beam to column joints, column bases, beam to beam joints, importance of joint behaviour for the overall frame behaviour, modelling of joints for static analysis, iterative procedure of member and joint design in a frame structure, component method, components of welded and bolted beam to column joints, T-stub and failure modes. Application examples.	1×4=4

#	Title	Description	Hours
3	Conceptual design and sizing of typical connections	Conceptual design of typical connections, beam to column connection, beam to beam, head-beam to column connection, brace to column to head-beam connection, roof bracings to girder and purlin connection, column bases. Shop drawings: general layout, assembly and part drawings, fabrication (cutting of parts, drilling of holes, assembly of transportable parts via welding), on-site erection process employing bolted connections as much as possible.	1×4=4
4	Seismic design	Brief introduction to the concept of capacity design, advantages of steel as structural material exhibiting good performance under seismic actions, ductile and brittle failure mechanisms of steel members and connections. Lateral load resisting systems for steel structures: Moment-resisting frames, concentrically and eccentrically braced frames, conceptual design, behaviour factors, capacity design rules, ductile members, overstrength factors of brittle members, benefits of capacity design. Application examples.	3×4=12
5	Conceptual design of typical steel structures	Principles of conceptual design for typical one-story and multi-story steel buildings, analysis of the behaviour and the function of primary and secondary elements of the load resisting system, importance of conceptual design for the safety, economy and constructability. Practical applications.	1×4=4
6	Overhead crane runway beams	Overhead crane types, actions, load combinations, ultimate and serviceability limit-state verifications, EC3 provisions. Application examples.	2×4=8
7	Design for corrosion and fire actions	Corrosion protection of steel structures, typical damage due to fire, fire protection measures, fire resistance index, effect of temperature on the mechanical characteristics of steel, standard temperature-time curve (ISO), steel temperature increase (protected and unprotected members), fireproofing materials, fire load, design actions under fire, resistance of steel sections according to EC3. Application examples.	1×4=4
8	Design of plate girders	Introduction to plate buckling, buckling of non-stiffened webs, category 4 sections, calculation of effective section, verifications of sections and members according to EC3, resistance to shear buckling, interaction of action effects, resistance to concentrated forces, introduction to buckling of stiffened plates. Application examples.	2×4=8

Learning Objectives

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

- select the structural system for simple steel structures subject to static and dynamic (seismic) loads;
- select appropriate types for section members and connections;
- size members and connections;
- prescribe surface protection measures.

Pavements

Course Description

Students will focus on issues related to the design of flexible, semi-rigid, semi-flexible and rigid road and airfield pavements. Basic differences between road and airfield pavements. Methodologies for the design of road and airfield pavements, mechanical characteristics of materials, mix design in the laboratory and quality control.

Semester: 7

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Mechanical characteristics of materials used in road and airfield pavements	Mechanical characteristics of the materials considered during mix design in the laboratory. Comprehension exercises in class.	1×4=4
2	Mix design	Mix design in the laboratory and testing.	1×4=4
3	Traffic, axle loads, pavement distress	Basic traffic assumptions for pavement design.	1×4=4
4	Mechanical damage-failure	Failure criteria of pavements, analytical calculation of stress-strains and mechanical damage.	1×4=4
5	Principles of analytical and empirical design of pavements	Basic principles of flexible, semi-rigid, semi-flexible and rigid pavement design. Principles of analysis and design. Basic differences between road and airfield pavements.	2×4=8
6	Road pavement design methods	Basic methodologies for designing flexible and rigid pavements (AASHTO). Comprehension exercises in class.	2×4=8
7	Airfield pavements and design	Characteristics of airfield pavements, pavement types and areas of application, aircraft loading. Principles of airfield pavement design and widely accepted methodologies for flexible and rigid airfield pavement design (FAA). Comprehension exercises in class.	3×4=12
8	Paving - construction technologies and quality control	Basic technologies / processes for the construction of pavement layers. Quality control during the individual construction stages for quality assurance.	1×4=4
9	Project delivery-Technical characteristics	In-situ measurements for checking the condition of the final asphalt surface layer for final pavement delivery.	1×4=4

Learning Objectives

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

- evaluate types of mixtures in the laboratory;
- implement methodologies for the analysis and design of all types of pavements;
- make use of the possibilities of analysing and designing airfield pavements;
- be aware of the quality control requirements at the individual stages of construction of a pavement and during the final delivery;
- comprehend the content and importance of the Tender Documents for a pavement construction project.

Engineering Geology

Course Description

Engineering Geology and Geotechnical Engineering. Properties of the rock material-intact rock. Rockmass behaving as an equivalent discontinuum. Geotechnical classification of rocks and rockmasses. Principles of site investigations. Geology and rock slope stability. Dam geology and reservoirs. Geology and underground works - tunnels. Geology of Greece and case histories of engineering works.

Semester: 7

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Engineering Geology issues and applications in engineering works. Case studies.	1×3=3
2	Intact rock	Strength and deformability of intact rock. Failure criteria.	1×3=3
3	Rockmass	Strength and deformability of rockmass. Classification. Empirical systems. Failure criteria.	1×3=3
4	Discontinuities	Description, engineering characteristics, shear strength. Stereographic projection using Schmidt stereonet.	2×3=6
5	Rock slope instability	Determination of potential rock slope failures. Use of Schmidt stereonet.	3×3=9
6	Dam Geology	Types of Dams. Geological conditions in dam sites. Site investigation in dam sites. Permeable geological formations and seepage under dams. Dam reservoir and leakage. In situ tests for permeability determination. Characteristic examples of dam failures.	3×3=9

#	Title	Description	Hours
7	Geology and underground Works	The role of Geology in underground works. Methods of excavation and support of tunnels. The geological conditions in Greece and the behaviour of geological formations in the tunnel excavation.	2×3=6

Learning Objectives

With the successful completion of the course, students will be able to: know the physical and mechanical characteristics of the rocks and understand the geologic problems related to the instability of slopes, the dam construction and the excavation of tunnels in rock masses.

Open Channel And River Hydraulics

Course Description

One dimensional analysis of the flow with free surface, in prismatic channels and natural streams. Emphasis is concentrated on the steady state flow which is studied in detail, while elements regarding the time depended, unsteady flow are presented as well.

Semester: 7

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction, Critical flow theory	Review of the material taught in Hydraulics & Hydraulic Works course. Specific energy, specific force and discharge equations and diagrams, critical depth. Critical flow theory applications, smooth bottom elevation and width reduction, flow chocking.	1.5×4=6
2	Uniform flow	Manning equation, uniform flow calculation in prismatic channels, compound channel calculation, compound roughness. Design of lined and unlined channels for uniform flow, the best (optimum) hydraulic section.	1.5×4=6
3	Gradually varying flow I (GVF-I)	Non uniform, gradually varying flow (GVF). Classification and types of free surface profiles. Qualitative analysis, control sections. Computation of the GVF in prismatic channels and natural streams. Outlet and entrance condition, channel reservoir connection. Complex problems.	2×4=8
4	Gradually varying flow II (GVF-II)	Introduction to HEC-RAS software.	1×4=4

#	Title	Description	Hours
5	Rapidly varying flow I (RVF-I)	Hydraulic jump. Characteristics and control of the hydraulic jump. Energy dissipation, stilling basins, (conventional and flip bucket), free fall steps.	2×4=8
6	Rapidly varying flow II (RVF-II)	Thin and wide crested weirs, side weirs, dam overflows (Ogee weirs), stepped spillways, tainter gates.	1×4=4
7	Channel transitions, culverts, channel junctions and divisions	Channel transitions in subcritical flow. Curves and transitions in subcritical flow. Curves and transitions in supercritical flow, oblique jump. Bridge piers, culverts, channel and river junctions and divisions.	2×4=8
8	Spatially varying flow	Equations of the spatially varying flow, computation of side overflows and bottom racks.	1×4=4
9	Unsteady flow	Spatially and temporally varying flow. St. Venant equations. Kinematic wave, stage-discharge relationship, rapidly varying flow, flood routing, hydrological methods (Muskingham), etc.	1×4=4

Learning Objectives

Upon the completion of the course a student will have the ability to compute the flow in one dimension in prismatic channels, culverts, dam overflows, stilling basins and other related hydraulic structures. Also, the student becomes familiar with HEC-RAS software which is the necessary tool for the computation of steady as well as unsteady flow in channels and natural streams.

4.8 8th Semester

Coastal Engineering

Course Description

This course aims to provide students with specialized knowledge on mechanisms of coastal sediment transport, morphological feedbacks to the structures and coastal erosion. It also aims at learning the design and spatialisation of coastal protection projects using relatively simple mathematical expressions and advanced mathematical models.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduction to Coastal Engineering. Coastal Engineering and its field.	3

#	Title	Description	Hours
2	Wave Mechanics Elements	Waves in coastal area (shoaling, refraction, diffraction, breaking, run-up). Coastal circulation, currents (tidal, wind-, wave, density) and mathematical coastal circulation models. Radiation stress theory.	6
3	Marine sediments and Sediment Movement Sediments	Sediment movement, sampling, statistical parameters. Drilling stress at the bottom. Bottom roughness. Friction coefficient. Start of movement. Placement in sediment suspension. Transfer of sediment to the coastal zone. Neutral line. Sediment motion monitoring techniques.	9
4	Coastal sediment transport and sediment balance	Sediment transport vertically and along the coast. Calculation of sediment supply. CERC methods, et al. Sediment accumulations in the coastal zone. Natural accumulations. Effects of coastal barriers and projects. Mathematical study of coastline development.	9
5	Coastal protection projects	Introduction to coastal protection projects. Types of coastal structures. Structures along the coastline. Structures perpendicular to the shoreline. Coast replenishment. Basic operation and construction parameters.	12

Learning Objectives

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

- understand the basic principles of coastal sediment transport and morphological feedbacks from technical works through equations and simple numerical models;
- understand the mechanisms of erosion and sedimentation in the coastal zone;
- solve basic components of coastal engineering problems by understanding the processes of wave propagation in coastal areas and the interaction of waves with coastal structures;
- design of coastal protection structures using empirical relationships and mathematical models.

Finite Element Analysis of Structures

Course Description

The aim of the course is to provide students with a thorough understanding of the fundamental concepts and principles of finite element analysis with a focus on linear elasto-statics. Furthermore, the course provides an introduction on the programming aspects of the method through hands-on programming workshops. Simulation strategies and the implementation of the method on real-life applications are also discussed.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Weak formulation, Principle of minimum total potential energy, FEM discretization, the Galerkin method, strain displacement matrix, stiffness matrix and equivalent load vector	6
2	Uniaxial elements	Two and three node truss elements, 2D beam elements, transformation matrices, equivalent loads and boundary conditions	4
3	2D Elasticity	Constant Strain Triangle, quadrilateral plane stress/ strain elements, Lagrange and higher order shape functions, Serendipity elements, quadrature rules	6
4	3D Elasticity	Tetrahedral and hex elements, linear and higher order shape functions, Lagrange and Serendipity elements	3
5	Isoparametric formulation	General description of the isoparametric mapping, Cartesian and natural coordinate systems, isoparametric truss, plane stress and hex element, higher order elements, Numerical quadrature	9
6	Simulation of structures	Best practices, error estimation and stress recovery, mesh additivity, kinematic constraints, Connection of different types of elements. Rigid offsets and diaphragms.	12
7	Programming workshops	Programming the finite element method. Hands-on programming workshops. Introduction to the use of finite element programs - troubleshooting. Simulation strategies, implementation on real-life applications.	12

Learning Objectives

- To develop an understanding of the basic principles of FEM as a method of solving systems of differential equations and its specialization in problems of simulation of mechanical systems and structures.
- To become familiarized with rules of simulation and use of computer tools (commercial programs and source codes).

Renewable Energy and Hydroelectric Projects

Course Description

Renewable energy sources, with emphasis to hydroelectric energy. Electric energy demand (components, temporal distribution). Hydropower technology – preliminary design. Large hydroelectric works: general layout, technical quantities, environmental issues, reservoir operation, simulation and optimization. Small hydropower works: technology, design, environmental issues. Solar and wind energy: estimation of solar/wind potential, system design, allocation, legislation. Hybrid systems – pumped-storage. Energy economics. Water and energy.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Energy, electric energy and renewable energy	Historical background. Basic concepts of energy technology. Forms of energy. Electric energy. Energy mix. Electrical systems. Renewable energy sources. Hydroelectric energy.	3
2	Energy supply and demand	Electric energy balance. Energy demand and its components (domestic, industrial, municipal, agricultural). Temporal distribution of energy consumption. Forms of energy production (base energy, peak energy, secondary energy).	3
3	Principles of hydropower technology	Fundamental quantities (energy, power, hydraulic head, efficiency). Estimation of hydraulic losses. Turbine types. Characteristic turbine curves. Preliminary design of hydropower systems.	3
4	General layout of hydroelectric works	Dams and associated works (intakes, penstocks, power stations, draft tubes, spillways, gates). Environmental impacts. Examples.	3
5	Hydroelectric reservoirs	Characteristic properties. Water balance. Multi-reservoir systems. Multi-purpose reservoirs. Operation rules. Environmental constraints. Flood control.	3
6	Simulation and optimization of hydroelectric reservoirs	Hydrological uncertainty and its impacts to hydropower design. Hydrological design of reservoirs. Simulation and optimization techniques for hydroelectric reservoirs. Estimation of firm and secondary energy.	3
7	Technology of small hydropower works	General layout of small hydropower plans. Main components (intake weirs, transfer channels, forebay tanks, penstocks). Specific environmental utilities (sediment stops, fish passages). Examples.	3
8	Design of small hydropower works	Hydrological design. Flow duration curves. Ecological flows. Simulation of small hydropower plan operation. Turbine selection. Optimization of energy production through combined turbines.	3
9	Solar energy	Solar radiation (direct, diffuse). Measurement of solar radiation. Estimation of solar energy potential. Estimation through indirect data (daylight hours, cloud data). Impact of topography. Allocation of solar panels. Legislation.	3

#	Title	Description	Hours
10	Wind energy	Theoretical and technically efficient wind potential. Wind power curves. Allocation of wind plant systems. Legislation. Environmental impacts and associated constraints.	3
11	Hybrid systems	The concept of pumped storage. Reversible turbines. Simulation of hybrid system operation.	3
12	Energy economics	Energy and hydroelectric energy management. Technical and economic quantities. Energy market.	3
13	Combined management of water and renewable energy	Conjunctive management of water and renewable energy Water as a means for energy production, consumption and storage. Conjunctive management of hydroelectric, wind and solar energy at large scale.	3

Learning Objectives

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

- estimate hydropower potential;
- perform hydrological design and management of small and large hydropower projects;
- estimate solar and wind potential;
- estimate energy production through renewable sources;
- address institutional and environmental issues (environmental impacts, constraints, allocation, legislation);
- evaluate feasibility and effectiveness of energy projects;
- recognize the concept of combined management of water and energy resources.

Pavement Evaluation and Maintenance

Course Description

Students will focus on issues related to the assessment of the structural and functional condition of road and airfield pavements, through in-situ measurements, in the framework of periodic Pavement Monitoring Systems. Decisions making in terms of maintenance, reinforcement or reconstruction of pavements. Useful techniques in terms of maintenance management and sustainability of pavements.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Pavement behaviour-Serviceability of road and airfield pavements	Pavement behaviour and serviceability for road and airfield pavements.	1×3=3
2	Assessment of structural condition of pavements	Basic principles / methodologies for estimating the bearing capacity of pavements. Importance of using non-destructive testing and geophysical methods on pavements. Usefulness of visual inspection for monitoring surface distresses on pavement. Destructive testing for estimating road and airfield pavement characteristics in the laboratory.	2×3=6
3	Airfield pavement reporting	Importance of airfield pavement reporting with emphasis on international reporting method of ICAO (ACN / PCN). Methodology for determining the bearing capacity of a pavement (FAA). Comprehension exercises in class.	2×3=6
4	Assessment of functional condition of pavements	Functional characteristics of pavements (riding quality, skid resistance, texture). Comprehension exercises in class.	2×3=6
5	In situ Non-Destructive Testing (NDT) systems	In-situ Non-Destructive Testing (NDT) systems for monitoring pavement condition and related assessment.	1×3=3
6	PMS	Pavement Monitoring Systems (PMS) for road and airfield pavements.	1×3=3
7	Maintenance-reinforcement-reconstruction	Basic principles and technologies for pavement reinforcement and rehabilitation. Basic methodologies for pavement reinforcement (AASHTO). Comprehension exercises in class.	3×3=9
8	Sustainable pavements-Life cycle	Basic methodologies and techniques applied in terms of pavement sustainability. Life Cycle Analysis of pavement.	1×3=3

Learning Objectives

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

- evaluate the structural and functional condition of a pavement within the framework of serviceability;
- be aware of the usefulness and the way of implementation of Pavement Monitoring Systems for roads and airfields;
- analyse and evaluate the results of non-destructive testing in terms of pavement assessment;
- apply widely accepted methodologies for road pavement reinforcement;
- comprehend the processes used for the evaluation of road and airfield pavements;
- implement appropriate methods for evaluating road and airfield pavements distinctly;

- choose appropriate pavement rehabilitation technologies.

Structural Reliability and Risk Analysis

Course Description

Probabilistic models of random variables (Loads, resistances, geometry etc.). Estimation of failure probability and design point. Models of systems and processes (series and parallel systems). Linear and nonlinear limit-state functions. Dependent and independent random variables. Load combinations. Probabilistic assessment of safety factors. Probabilistic natural hazard models. Fragility and exposure. Risk, fragility curves and decision analysis.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Probabilistic models	Modelling of loads and resistances. Load combinations. Series and parallel systems	2×3=6
2	Limit-state function. Probability of failure.	Second-order methods. Dependent and independent random variables. Linear and nonlinear limit-state functions. Monte Carlo simulation methods	2×3=6
3	Load combinations	Load combinations. Assessment of safety factors	2×3=6
4	Structure and infrastructure risk	Total probability theorem. Risk Assessment. Methodologies with and without an interface variable (requirements of sufficiency and efficiency). Probabilistic models of natural hazards. Assessment of hazard at one or multiple sites. Fragility curves and surfaces for one component or a class of components. Assessment of losses based on global or local data. Decision analysis. User risk preference.	5×3=15
5	Applications	Applications and solution of example cases. Building or bridge, reservoir, offshore structure.	2×3=6

Learning Objectives

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

- rationally take into account the uncertainties when designing civil engineering projects, including structural, hydraulic and geotechnical infrastructure;
- estimate the probability of failure of a complex civil engineering project;

- design a structure or any other complex system with an acceptable probability of failure;
- assess structure and infrastructure risk under natural and man-made hazards;
- make decisions under uncertain information.

Urban Road Networks

Course Description

Urban Road Networks is part of 8th semester courses. It is compulsory for the students at the Transportation Planning and Engineering cycle. Lectures include design principles of urban road networks and more specifically of junctions (at grade or not), traffic signals, road signs and parking design and management. The course also includes parking counts by the students. Based on these counts students analyse the parking characteristics and the design of a parking area and optimize the signalization at an individual junction. The course foresees four hours of theory and exercises every week. During the exercises practical examples of applications are developed and in general the overall understanding of the course is assisted. It should be noted that there is no clear distinction between theory and exercises, since the theory relies on exercises and exercises deal with questions about the theory. Students participate in one class.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Definitions Urban transport systems Traffic control systems in urban networks Parking and traffic management	1×4=4
2	Traffic capacity and signalisation in urban road networks	Introduction - signalisation conditions Definitions - basic signalization principles Saturation flow Two-phase signalling: calculation saturation flow Intermediate green time Calculation of critical lane groups Optimization of signalization of an isolated junction Signalling a T-type intersection with pedestrians Coordinated signalization of an artery Network signalling systems Unsigned intersections	5×4=20
3	Parking	Introduction - Definitions Parking characteristics - Surveys Parking places characteristics Multilevel parking stations - Bus stations Construction - Operation Design and operation of parking stations Characteristics of parking on the road Parking economics	5×4=20
4	Road signs	Road signs and work-zones Road markings	2×4=8

Learning Objectives

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

- learn the main types of signalisation and parking management;

- realise the ability to improve traffic flow through traffic control and parking management;
- understand the value of design principles for the signalization of a road network and the existence of regulations for the design of parking spaces;
- develop signalizing and parking principles;
- estimate through design principles basic parking and signalized parameters.

Rock Mechanics - Tunnels

Course Description

Discontinuities and their effect on rockmass behaviour. Rock mass classification systems (Deere, RMR, NGI, GSI). In situ stresses. Models of mechanical behaviour. Failure criteria of intact rock and rockmass. Physical properties and mechanical parameters, laboratory and in situ tests. Stability of rock slopes (plane, wedge and circular failure).

Stress and deformation distributions around deep and shallow tunnels under elastic or elasto-plastic conditions. Rockmass loosening pressures, convergence-confinement curves, principles of the NATM method, temporary tunnel support and interaction with rockmass. Mechanical tunnelling methods (TBM). Pressures on the permanent lining of tunnels.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Rock Mechanics: Introduction	Development and applications of Rock Mechanics. Rock and rockmass	1×4=4
2	In situ stresses	In situ stresses. Origin and distribution with depth in regions with deferent tectonic regime. Methods of measurement.	1×4=4
3	Intact rock	Physical characteristics; mechanical behaviour (strength-deformability) and failure criteria of intact rock. Classification.	1×4=4
4	Rockmass	Rockmass discontinuities. Physical and mechanical characteristics and shear strength of discontinuities. Rockmass mechanical behaviour (strength-deformability) and failure criteria. Classification systems of rockmass (RMR, NGI, GSI).	1×4=4
5	Rock slope stability	Types of rock slope failures (planar and wedge slide; circular slide; toppling). Calculation of the factor of safety. The effect of water pressure and seismicity.	2×4=8

#	Title	Description	Hours
6	Excavatability and foundations in rock	Methods of rockmass excavation. Empirical systems for rockmass excavatability based on rockmass characteristics (strength, discontinuities condition, jointing). Foundation methods on rock and problems. Bearing capacity.	1×4=4
7	Introduction in Tunnels	History of tunnelling, Conventional (NATM) and Mechanical (TBM) Tunnel Excavation	1×4=4
8	Convergence - Confinement	Convergence – Confinement curves	1×4=4
9	Convergence - Confinement	2D Modelling using internal pressure reduction and modulus reduction	1×4=4
10	NATM Method	Use of shotcrete, rock bolts and anchors, steel sets, multiple excavation stages	1×4=4
11	Numerical Methods	Use of computer software PHASE2 in 2D numerical Analysis	1×4=4
12	Final Lining	Loads on final lining of tunnels	1×4=4
13	Face stability	Analysis of tunnel face stability	1×4=4

Learning Objectives

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

- know the principles of strength and deformability of rocks and their engineering behaviour in the construction of engineering works and especially the tunnels;
- know the basic principles of tunnel design and the main tunnel construction methods;
- perform numerical and computer analyses in rock mechanics problems (slope stability, foundations, excavability) and in tunnel design.

Bridge design I

Course Description

Introduction to bridge design, geometrical design of bridges, loads on bridges, analysis and design of steel and composite bridges.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction to bridge design	Introduction, principles and criteria for bridge design, general layout, selection and planning of the structural scheme, piers, foundation types, bridge aesthetics	12
2	Specifications and Codes, loads on bridges, Ultimate and Serviceability Limit States	Specification frame for bridges, bridge loads to EN 1991, limit states to EN 1990	4
3	Analysis and design of Steel and Steel-Concrete Composite Bridges	Conceptual design of steel and composite bridges Building materials Deck slab, transverse girders Models and methods of analysis for steel and composite bridges ULS and SLS verifications Plate buckling Stability at construction and service stages Fatigue Construction details	36

Learning Objectives

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

- comprehend the basic principles for design of the superstructure, the piers and the foundations;
- design conceptually steel and composite bridges;
- determine the loads to Eurocodes;
- comprehend the methods of analysis and construction stages of bridges;
- verify the members of steel and composite bridges to Eurocodes 3 and 4.

Flood Risk Management

Course Description

[Missing information]

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	[Missing information in the English transcript]	[Missing information in the English transcript]	1×4=4

#	Title	Description	Hours
2	[Missing information in the English transcript]	[Missing information in the English transcript]	4×4=16
3	[Missing information in the English transcript]	[Missing information in the English transcript]	3×4=12
4	[Missing information in the English transcript]	[Missing information in the English transcript]	3×4=12
5	[Missing information in the English transcript]	[Missing information in the English transcript]	2×4=8

Irrigation Engineering

Course Description

Basic principles, design and operation of irrigation works. Irrigation water requirements, irrigation water delivery systems and crops irrigation methods, sources and quality of irrigation water and soil. Irrigation pumps, flow measurement devices, irrigation water management, environmental consequences, legislation of water resources availability.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Basic principles and definitions. Historic evolution of irrigation studies and works. Pre-study of irrigation works and geotechnical/economic assessment.	
2	Crops and irrigation	Crop-soil-atmosphere relationships. Measurement of soil water capacity, useful soil water capacity, description of root zone systems - crop water uptake. Methods of computing reference crop evapotranspiration (physically and empirically based). Crop growth stages, crop coefficient and actual crop evapotranspiration.	3
3	Irrigation water requirements	Methodology of estimating the gross irrigation water requirements and the irrigation scheduling (irrigation dose, time, frequency and efficiency) including water to combat soil salinity.	3

4	Design discharge of irrigation networks	Design water supply of irrigation networks under the water distribution systems of continuous water supply, rotation and free demand (probability concept).	3
5	Surface irrigation methods	Basic principles and computational methods for the design and operation of surface irrigation systems (flood irrigation, limited diffusion or furrows). Assessment of topsoil surface irrigation water flow characteristics. Assessment of computational methods of surface irrigation and water reuse from surface irrigation water losses.	6
6	Sprinkler irrigation systems	Hydraulics, design and operation of sprinkler irrigation systems. Water distribution uniformity and types of sprinkler irrigation systems (e.g. portable, semiportable, permanent systems). Move-set and solid-set irrigation systems. Sprinkler system components (pumps, main and lateral lines, sprinklers) and performance characteristics. Hydraulic computations for the assessment of flow characteristics in pipes of individual and collective sprinkler irrigation networks. Specific sprinkler irrigation systems for environmental protection, and injection of fertilizers, chemical ingredients and fluid waste.	6
7	Local and trickle irrigation	Methods of local irrigation: trickle, sub-surface irrigation, fountain and spraying irrigation. Irrigation system components (e.g. drippers, microjets: technology and hydraulics. Uniformity of irrigation water distribution. Irrigation layouts. Hydraulic calculations for the design and good operation of network pipes due to small design discharges. Control systems of hydraulic head for purely irrigation water and water mixed with chemicals and fertilizers. Pumps installations, cleaning filters, equipment of chemicals injection, flow and pressure meters, and automation equipment. Management and evaluation.	6
8	Pumps for crops irrigation systems	Description of typical parameters and efficiency characteristics for two or more pumps operating in series or in parallel. Pump efficiency consequences from speed and diameter changing of an impeller. Pump efficiency curves and irrigation system required for determining the hydraulic head and operation discharge of one or more pumps. Criteria for selecting the most suitable pump or combination of pumps.	3
9	Advent and quality of irrigation water-environmental consequences	Description of surface water sources for crop irrigation (rivers, lakes, central irrigation water distribution facilities, industrial and agricultural returns and urban waste), groundwater (subsurface aquifers) and irrigation wells. Suitability conditions and irrigation water quality criteria (e.g. salinity, toxicity, content of exchangeable sodium, biocides, carbonate anions, suspended materials). Classification systems according to the appropriateness. Supply rate of water resources and soil improvement. Environmental consequences and irrigation water legislation particularly for territorial waters and water appropriation.	3

10	Flow meters in irrigation systems	Discharge measuring methods and devices in irrigation systems and open channels. Discharges and design of measuring devices in special applications (e.g. ultrasonic meters with or without application of Doppler phenomenon, Pitot pipelines, etc).	3
11	Drainage and drainage systems	Definition, necessity and factors influencing drainage. Drainage from soil surface and root zone of crops. Surface water drainage with trench networks and root zone drainage with underground closed drainage pipes-drainage networks. Drainage network design (layout, maximum flow, depth, equilibrium, dimensioning and technical works). Design under constant flow conditions (equivalent depth method) and unstable flow (Boussinesq equation). Hydraulic calculations of drainage pipes (pipelines and drainage ditches). Drainage water pumping (design, operation and maintenance). Relief of aquifer or artesian wells (design, construction, operation, maintenance and disposal of water). Economic, legislative and environmental issues. Return flow and sewage disposal.	6

Learning Objectives

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

- understand the crop-soil-atmosphere relationship;
- estimate the crop evapotranspiration using empirical and physically based methods;
- compute the water irrigation requirements, specific discharge, dose, frequency and duration of irrigation applications;
- design the discharges of irrigation networks according to delivery systems of irrigation water;
- apply the irrigation methods: surface, sprinkle and local (trickle irrigation);
- design the irrigation networks;
- understand the origin and quality of irrigation water and soil, as well as the suitability criteria of their use;
- understand and design the functionality of irrigation pumps;
- understand water measuring devices and their operation in irrigation systems;
- manage the irrigation water and environmental consequences coming from irrigation works.

Advanced Geotechnical Works

Course Description

Following an introduction on types of dams and auxiliary works, the course focuses on embankment dams, and the geotechnical issues that govern their analysis, design and construction: water seepage, static and seismic stability of their slopes, settlements, clay core compaction, filter and drains.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Types of dams – auxiliary works	Basic definitions. Focus on types of dams (gravity, arch, earth dams, RCC, etc.) and on auxiliary works (spillways, gates, etc.).	2×3=6
2	Embankment dams	Description of different types of embankment dams, as a function of employed materials and restrictions due to insitu conditions. Numerical analysis of embankment dam construction.	1×3=3
3	Seepage through soil	Introduction – Review of Darcy and Bernoulli equations for water seepage through soil. Laplace equation for water seepage in 3 dimensions. Flow nets. Numerical analysis of seepage through an embankment dam.	2×3=6
4	Static stability of embankment slopes	Basic definition. Methods of slices for slope stability, analyses for effective and total stresses. Design States: End-of-Construction, Steady-State Seepage, Rapid Drawdown. Calculation of Factors of Safety.	3×3=9
5	Seismic stability of embankment slopes	Design earthquakes. Pseudo-static analysis, selection of seismic coefficient, sliding-block analysis and estimation of slope displacements. Calculation of Factors of Safety and permanent slope displacements. Numerical analysis of seismic loading of an embankment dam.	3×3=9
6	Construction issues for embankment dams	Reservoir loss reduction, clay core compaction and densification of shells, design of filters and drains	2×3=6

Learning Objectives

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

- know the main categories and characteristics of dam types and their auxiliary works, with the knowledge being broader for embankment dams and their construction issues requiring solution;
- compute with the aid of related software: a) static and dynamic factors of safety of embankment dam slopes, b) permanent slope displacements and settlements under seismic loading, c) seepage through and under embankment dams;
- design a zoned embankment dam, in terms of composition of filters and drains, the (static and seismic) stability of its slopes, and the water loss due to seepage through and under its mass;
- understand the use and the limitations-problems of numerical analysis of embankment dam construction and embankment dam response under seismic loading.

Special Topics of Road Geometric Design

Course Description

Introduction to the geometric design of intersections and interchanges and their design at pre-final stage, through PC software in digital environment. The aim is to familiarize students with contemporary road design processes as well as the development of critical thinking and synthesis of knowledge from the bibliography for the formulation of specific suggestions - solutions related to basic of road safety aspects.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Road contour configuration	Road surface altitude configuration, approach grade at intersections.	1×4=4
2	Aspects of urban road design	Urban road design issues (mild traffic, shared space, etc.).	1×4=4
3	Intersections (conventional)	Intersection types, horizontal design, longitudinal design, edge-lines, visibility, layout elements, islands, small and large intersection types.	1×4=4
4	Intersections (roundabouts)	Types, horizontal design, longitudinal design, configurations, visibility, aspects of operational analysis.	1×4=4
5	Interchanges	Types, selection criteria, interchange operational area, distances, lane equilibrium, weaving, collector – distributor roads, exits - entrances from - to ramps, visibility, horizontal – vertical – cross sectional geometric design (main road and ramps, curved exits, entrances, ramp lengths, acceleration – deceleration lanes).	2×4=8
6	Road side equipment	Vehicle restraint systems EN1317.	1×4=4
7	Road side equipment	Passive safety road equipment EN12767, basic aspects for horizontal road markings and vertical road signage.	1×4=4
8	Special issues for determining critical road geometric parameters	Determination of critical road geometric parameters based on vehicle dynamics, variable grades, 3D visibility.	1×4=4
9	Human factor in road design	Human factor in road design.	1×4=4
10	Road safety audits	Introduction to road safety audits, process, control steps, road safety auditors - inspectors, conducting road safety audit on urban freeway.	2×4=8

#	Title	Description	Hours
11	Course synopsis	Course synopsis, project delivery,	1×4=4

Learning Objectives

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

- participate in the computer aided road and intersection – interchange design at pre-final stage;
- evaluate key road safety problems by suggesting relevant improvements to under design or existing road sections.

Light Metal Structures

Course Description

Introduction to cold-formed steel members and structures. Material properties. Corrosion - Hardening. Classification of steel sections. Plate buckling. Effective width of compression steel plates. Effective cross-sections with stiffeners. Moments and warping resistance. Axial, bending and shear distress of cold-formed members. Uniform and non-uniform torsion. Flexural-torsional distress and buckling. Diaphragms, longitudinal stiffeners. Design and calculation of connections. Secondary effects in connections. Beams and Corrugated metal sheets. Shear resistance of metal panels. Code requirements for thin-walled steel members.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Introduction to cold-formed steel members and structures.	2
2	Material properties	Corrosion - Hardening	4
3	Plate buckling Effective width	Plate buckling. Effective width of compression steel plates. C-sections and Z-sections with stiffeners according to EC3-Part 1.3	12
4	Metal sheets	Corrugated metal sheets	6
5	Buckling	Global and local buckling. Lateral buckling.	6
6	Connections	Design and calculation of connections. Secondary effects in connections.	6
7	Beams	Design in bending and shear according to EC3-Part 1.3	8
8	Torsion	Open and closed cross-sections in torsion	4
9	Diaphragms	In-plane shear panels	4

Learning Objectives

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

- determine the effective cross-section and the corresponding strengths of cold-formed steel sections according to EC3-Part 1.3;
- determine the carrying capacity of cold-formed section members under combined loading;
- design structures with cold-formed section members and connections according to the provisions of EC3-Part 1.3.

Quality Control and Quality Assurance

Course Description

[Missing information in the English transcript]

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Basic concepts	Definition of Quality, Difference between Quality and Category. The Cost of Quality. The tools of Quality	3
2	Quality Management System (QMS)	Quality management systems: Requirements, Development and Documentation. The Project Quality Plan (PQP). Development of a PQP for technical projects. Implementation a PQP in a construction company.	9
3	Quality foundations	Standardization, Metrology, Compliance Assessment. Regulation EU No 305/2011 -construction products. The CE marking. The interconnection of Quality Management System, Safety and Health Management System and Environmental Management System in the technical project.	9
4	Conformity Criteria	Producer’s and consumer’s risk. Control by attributes, control by variables. Operating curves	6
5	Shewhart charts	Production under statistical control. Mean value and range diagrams. Limits of immediate action,	6
6	Cusum diagrams	Deviation from the mean value. Estimation of variability. Decision lines. Sampling frequency.	6

Learning Objectives

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

- Be able to implement and use quality management systems;

- be able to develop Project Quality Plan and to use basic functions of commercial software;
- be able to understand and develop conformity criteria depending on the consumer's and producer's risk;
- be able to follow the production process and intervening when the production is out of statistical control.

Complex Calculus

Course Description

Holomorphic complex functions. Complex integration, Cauchy-Goursat theorem and consequences. Taylor and Laurent series and singularities. The Residue Theorem and applications in the real integral calculus. Conformal mappings and applications in Partial Differential Equations.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introductory concepts	Complex numbers, modulus and polar form of a complex number, complex sequences and series, basic topological concepts in the complex plane.	1×4=4
2	Complex functions, differentiability and holomorphy	Complex functions, limit and continuity. Exponential function, logarithms and trigonometric functions. Differentiable complex functions, Cauchy-Riemann conditions, holomorphic complex functions.	2×4=8
3	Complex integration	Complex contour integral. Cauchy-Goursat theorem, Deformation Principle, Cauchy's Integral formulas, Liouville's theorem, Maximum Modulus Principle, harmonic functions, uniqueness of the solution to the Poisson problem.	2×4=8
4	Power and Laurent series, singularities.	Power series and convergence radius. Taylor's theorem and Taylor's expansions of basic complex numbers. Laurent series and isolated singularities: removable singularities, poles and essential singularities.	2×4+2=10
5	Residue theorem and applications	Calculus of Residues and Applications in the calculation of trigonometric and improper real integrals.	2×4=8
6	Conformal functions.	Conformal functions. Mobius transformations and applications in Boundary Value Problems (PDE's).	1×4+2=6

7	Conformal mapping	Conformal mapping. Mobius transformations, Riemann mapping theorem, Schwarz-Christoffel transformation. Applications of conformal mapping.	2×4=8

Learning Objectives

Upon successful completion of the course, students will have the following knowledge:

- basic concepts and results related to holomorphic functions, complex integration and conformal functions;
- applications of the above-mentioned concepts and results in real integral calculus and PDE's.

Timber Structures

Course Description

Introduction, areas of applications, comparison of structures made of different materials. Composition, properties, dampness of timber. Basic mechanical characteristics. Structural timber. Calculation principles, strength, forces, combination of forces. Calculation of timber structures. Joints (riveting, bolting, bonding), fabrication and design. Roofs. Frames. Panels. Scaffoldings, formwork. Bridges. Foundations. Durability. Earthquake resistant design of timber structures. The effects of fire on timber. Damage assessment and restoration.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Timber and environments: Photosynthesis process and the cycle of timber. Use of structural timber from ancient times till present. Structure- material properties of timber. Engineered wood products. Structural members. Loading limit states. Moisture and load duration states. Serviceability limit states.	3×2=6
2	Design check of sections	Design check of sections subjected to uniaxial stresses (tension, compression, bending, shear, torsion); parallel or at an angle to the grain. Design check under combination of stresses.	2×2=2
3	Design check of members	Columns and members subjected to buckling. Glulam profiles. Frames. Members with tapered, curved or pitched profiles.	3×2=6
4	Connections	Design of metal dowel type connections: bearing capacity of nails, dowels, bolts, staples. Design of joints with connectors: toothed plates, shear plates or rings.	5×2=10

#	Title	Description	Hours
5	Serviceability	Design check against deformations and vibrations.	2×2=4
6	Composite Sections	Glued or pinned sections. Built-Up, spaced and latticed columns.	3×2=6
7	Traditional Structures	Trusses without metallic connections (using compression force path).	1×2=2
8	Timber walls (panels)	With sheathing fixed to studs or with CLT.	2×2=4
9	Maintenance and repairing of structures	Design against earthquake and fire action. Damage and repair of timber structures. Durability in time.	1×2=2
10	Auxiliary structures	Scaffoldings, retaining structures, temporary supports.	1×2=2
11	Detailing	Nodes, hinges, foundation points, stability bracing,	1×2=2

Learning Objectives

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

- master the basic principles and the Codes' demands for the design of timber structures;
- design and perform all necessary calculations for the formation of a timber structure (members, connections, details), including detailing.

Reinforced Concrete III

Course Description

In this course, the design of reinforced concrete structures (RC) for seismic loading is considered, together with further design topics of RC structures. After the completion of the course the student will be able to design and detail RC structures under seismic actions; both aspects are considered, namely seismic performance and related design and construction aspects.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Basis of earthquake design	1×4=4
2	Materials' behaviour	Steel and concrete under cyclic actions	1×4=4

#	Title	Description	Hours
3	Pathology, Damages	Earthquake damaged structures	1×4=4
4	Ductility	Curvature and displacement ductility. Local and general ductility. Factor affecting ductility. Confinement.	1×4=4
5	Beams	Beams under seismic actions	1×4=4
6	Columns	Columns under seismic actions	1×4=4
7	Walls	Walls under seismic actions	1×4=4
8	Applications	Design of RC members under seismic actions	1×4=4
9	Anchorages, nodes	Maximum bar diameter passing through node. Node integrity	2×4=8
10	Struts and ties	Design with strut and tie models. Corbels. Deep beams	2×4=8
11	Deformations	Serviceability limit states. Deflection control. Long- and short-term deflections. Cases where calculations may be omitted	1×4=8

Learning Objectives

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

- know the performance of reinforced concrete under seismic response;
- understand the meaning and significance of the design and construction requirements, as well as the physical meaning of the design analysis models;
- design and detail a framed RC structure under seismic actions (reinforcement, detailing, drawings, sections etc.);
- design members for which plane section analysis is not fully applicable.

Nonlinear Structural Analysis

Course Description

The plastic consideration forms the basis of all modern design codes. This course provides the systematic teaching of the structural behaviour in the plastic region.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Importance of the plastic consideration	Advantages of plastic versus elastic structural analysis. Force redistribution. Ductility. Impact of the plastic approach on the Steel, Concrete and Earthquake Codes.	4
2	Pure plastic bending	Plastic bending. Rectangular Cross section. Steel and concrete cross sections. Beam of a general cross section.	4
3	Plastic bending with axial loading	Influence of the axial loading. Interaction surfaces. Unloading.	4
4	Influence of shear on the plastic behaviour	Plastic bending with shear.	4
5	Step by step elastoplastic analysis	Zero length plastic hinges. Step-by-step elastoplastic analysis of determinate and indeterminate structural systems using classical structural analysis. Estimation of the displacements prior to collapse.	4
6	PVW in the elastoplastic analysis	Formulation of the principle of virtual work (PVW) in the elastoplastic analysis. Statically admissible distribution of moments. Kinematically admissible mechanisms.	4
7	Plastic limit analysis theorems	Proportional loading. Lower and upper bound theorems of limit analysis. Significance of the lower limit in the design of structures. Connection with concrete and steel Codes. Theorem of uniqueness. Properties of the collapse load.	4
8	Estimation of the collapse load Independent mechanisms	Independent mechanisms. Method of superposition of mechanisms. Evaluation of the collapse load in framed structures.	4
9	Optimum plastic design	Optimum plastic design. Graphical solution.	4
10	Computational step by step elastoplastic analysis	Material nonlinear analysis. Development of the method-computational steps. Elastoplastic stiffness matrix (Plastic Flow Rule). Semester Project. Different simulations (concentrated, distributed plasticity).	4
11	Concentrated plasticity approach	Basic concepts. Simple and generalized yield criteria.	4
12	Distributed plasticity approach	Distributed plasticity. Introduction, difference with concentrated plasticity. Calculation of member forces.	4
13	Numerical and programming techniques in nonlinear analysis	Numerical techniques in computational elastoplastic analysis. Calculation of the tangent stiffness matrix. Newton-Raphson Method.	2

#	Title	Description	Hours
14	Dynamic plastic analysis	Plastic shear beam model. Formulation and solution of the equations of motion. Presentation of results and annotations for the case of seismic loading.	2

Learning Objectives

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

- know the basic principles of plastic behaviour of frame structures;
- understand the concept of collapse and the basic static behaviour principles that govern it;
- construct the collapse mechanisms in frame structures;
- calculate manually, but also computationally, the collapse load of frame structures.

Steel Structures III

Course Description

This course refers to stability of steel structures. Critical loads and buckling lengths of compressed elements as also critical moments of bending beams are calculated. The influence of initial defections and residual stresses is examined. The influence of bending loads on the behaviour of beam-columns (parts of frames or simple elements), is investigated. The impact of shear deformation on built-up columns is determined. Theoretical results are combined with EC3 regulatory provisions.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction. Higher order differential equation for columns.	Types of stability. Linear column theory. Calculation of critical loads and corresponding effective lengths. The influence of elastic supports on the critical load. Application examples.	6
2	Framed columns	Critical loads of frames and effective lengths of columns using neutral equilibrium. Application examples.	3
3	Beam columns	The influence of the axial compressive loading on beam-columns' behaviour subjected to lateral loads. Application examples.	3
4	Slope deflection method for frames with axially compressed members	Slope deflection equations in frames with simultaneously bending and axially compressed members. Application examples.	6

#	Title	Description	Hours
5	Influence of initial imperfection on buckling	Differential equation of equilibrium for members with imperfections (eccentrically axial loading, initially bent columns). Application examples.	3
6	Residual stresses of steel members	The influence of initial residual stresses on buckling behaviour of columns.	3
7	Code provisions for compressed members	Theoretical results are combined with regulatory provisions of EC3. Application examples.	3
8	Lateral buckling of beams.	Differential equations of bending beams in the deformed state of equilibrium. Calculation of critical moments. Theoretical results are combined with regulatory provisions of EC3	6
9	Built-up Columns	The influence of shear deformation in the resistance capacity of a built-up column is studied. Theoretical results are combined with the regulatory provisions of EC3.Examples of built-up columns are examined using EC3 specifications.	6

Learning Objectives

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

- calculate critical loads and effective lengths of axially compressed, members;
- estimate the influence of geometrical imperfections, residual stresses and shear deformation, on the resistance capacity of axially compressed members;
- understand the relation between theory of buckling and lateral buckling with the regulatory provisions of EC3;
- apply the EC3 procedure for buckling of built-up columns.

Railway Engineering

Course Description

The importance of Railways in transportation. Permissible loads. Axle loads regulation. Railway permanent way, Railway permanent way materials, rails, sleepers, fasteners, ballast. Static and dynamic loads and relevant calculations. Railway alignment design and geometry. Turnouts and crossings. Substructure: earthworks (excavations-embankments), drainage. Rolling stock (vehicles). Passenger coaches and freight wagons. Gauge, traction, train formation/composition. Railway stations. Rail freight transport. Railway freight terminals.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	The importance of Railways in transportation. Permissible loads. Static and dynamic loads and relevant calculations. Axle loads regulation.	1×4=4
2	Railway Permanent Way	Railway permanent way, Railway permanent way materials, rails, sleepers, fasteners, ballast. Railway gauges.	2×4=8
3	Train Guidance-Turnouts and crossings	Train guidance, train rolling. Turnouts and crossings (theory & exercises).	2×4=8
4	Traction and signalling	Traction, train formation/composition, signalling (theory & exercises).	1×4=4
5	Railway alignment design	Railway alignment design and geometry (theory and exercises).	3×4=12
6	Substructure	Substructure: earthworks (excavations-embankments), drainage. Special constructions (theory & exercises).	3×4=12
7	Rolling stock, Rail freight transport	Rolling stock (vehicles). Passenger Coaches and Freight Wagons. Railway stations. Rail freight transport. Railway freight terminals (theory).	1×4=4

Learning Objectives

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

- know the basic design principles of railway systems in respect to railway alignment design, turnouts, signalling as well as the basic characteristics of railway stations and vehicles;
- understand the interaction between the railway permanent way and substructure and the operation of railway systems;
- realize the significance of proper railway alignment design and the impact it has on railway operation (curves, turnouts, cant, railway permanent way);
- form an integrated structural and operational model of a railway system;
- calculate the rail track forces in relation to the type and characteristics of the passing rolling stock, cant in curves, wheel – rail interaction forces, load distribution from railway permanent way to substructure, signalling control, etc.

Steel-Concrete Composite Structures

Course Description

Introduction to the design of structural elements comprising of two materials, namely structural steel and reinforced concrete. Analysis and dimensioning of composite members (beams, slabs, columns), ultimate and serviceability limit state checks according to the Eurocodes and specifically with Eurocode 4. Design of buildings with composite structural members.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Buildings with composite structural elements, basic principles of the behaviour of structures with different materials: structural steel – reinforced concrete.	2
2	Structural Materials	Material properties according to Eurocode 4: Structural steel – concrete – reinforcing steel – bolts – steel sheeting.	2
3	Composite Beams: Analysis and ULS design	Calculation of cross-sectional properties, methods of analysis, moment resistance with plastic and elastic analysis, shear resistance, shear connection for the Ultimate Limit State.	16
4	Composite Beams: Analysis and SLS design	Calculation and checks of deflections, design against cracking and vibration for beams in the Serviceability Limit State. Construction phases. Detailing.	8
5	Composite Slabs: Analysis and design	Typology of composite slabs, methods of construction, ULS and SLS checks. Detailing.	8
6	Composite Columns: Analysis and design	Typology of composite columns, calculation of cross-sectional properties, plastic resistances, axial force & moment interaction, buckling checks, detailing.	12
7	Fire Design	Behaviour of materials of composite members under high temperatures, methods of design based on the time of exposure, the applied load or the method of construction. Simplified methods of design of composite beams, slab and columns.	4

Learning Objectives

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

- know the behaviour of members and structures of different structural materials;
- form buildings and other structures with structural steel and reinforced concrete members;
- distinguish the methods of analysis and construction phases of such structures;
- design composite beams, slabs and columns according to Eurocode 4.

Geographical Information Systems

Course Description

The scope of the course is to acquaint students with the basic principles of Geographic Information Systems (GIS) through their theoretical documentation as well as their practical training on subjects of interest. The main topics to be addressed include: Data collection, resources, legislation and technologies Data management, techniques, projection systems, databases Cartographic representation of the results, maps, graphs, etc. Basic data analysis methods, in vector format and in raster format.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction to GIS	Data collection, resources, legislation and technologies. Data management, techniques, projection systems, databases. Cartographic representation of the results, maps, graphs, etc. Basic data analysis methods, in vector format and in raster format.	21
2	Applications for civil Engineers	Physiographic characteristics of water basins. Spatial integration of point variables (IDW, kriging, cokriging). Spatial distribution of solar radiation. Estimation of sediment yield. Creation of sediment calculation process using model builder. Evaluation of flood parameters. Calculation of hydrographs using equal discharge times method	12

Learning Objectives

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

- comprehension of spatial distribution of environmental variables;
- estimate of spatial figures;
- chartography;
- use of GIS software.

Public Transit Planning

Course Description

Introduction to the Public Transit System. Analysis of passenger needs and requirements. Specification of basic technical, economic, social, and environmental constraints and parameters. Determination of technical specifications. Crew and bus scheduling. Pricing methods.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Characteristics of transport modes (metro, bus, tram). Public Transit systems.	1×3=3
2	Planning The Public Transit System	Planning the public transit system: basic definitions, brief presentation of models used in each planning step, forecast of demand, O-D surveys, study area, zoning, sampling and questionnaire design.	2×3=6
3	Specifications Of The Public Transit System	Specifications: service area, route length, planning new routes, level of service, frequency schedule, transfers, reliability, passenger comfort and safety, information provision and promotion, vehicle capacity, fare structure, prioritization.	3×3=9
4	The Athens Master Plan Of Bus Routes	Planning the Athens public transit system. Philosophy, alternative solutions, quantitative and qualitative criteria for evaluation. Implementation issues.	2×3=6
5	New Technologies	New technologies for the driver and the vehicle, information systems, autonomous driving, Last mile - first mile problem, car sharing and overall assessment.	1×3=3
6	Site Visit	OASA Control Centre	1×3=3
7	Scheduling	Bus route scheduling: determination of frequencies, crew and bus scheduling.	1×3=3
8	Pricing	Pricing methods: cost structure, operational cost, pricing policy, collection and analysis of data, business management.	1×3=3
9	Exams	Oral and written presentation.	1×3=3

Learning Objectives

- Familiarization with the specifications and planning methodology of the public transit system.
- Understanding the consequences of the planning process, through different examples.
- Familiarization with the operation and management of public transit.
- Passenger centric analysis and approach based on passenger needs and techno-economic, social and environmental constraints.
- Application of the planning process and implementation issues.

Building materials II

Course Description

Materials and design. Design process. Basic material properties (Weight-Density, Stiffness - Elasticity, Strength, Yielding, Ductility, Plasticity). Design based on features and properties. Vibration, resonance, rotation, circular loading. Fracture design. Thermal properties and behaviour. Design based on thermal behaviour. Durability and Corrosion. Design based on durability. Sustainability of materials and structures. Sustainability indicators. Design for Sustainability.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Materials - Properties-choice-design	Materials - Processes - Properties and Design. Organization of materials and processes, property and process relationship, material property diagrams, information management. Design process, materials and design data, case studies. Exercises.	2×3=6
2	Stiffness and weight: density and elastic moduli	Basic properties, material and property diagrams, parameters and attributes that define properties, density adjustment, and E. Exercises.	1×3=3
3	Stiffness-limited design	Typical solutions to elastic problems. Elastic design indicators, setting boundaries and design indicators in diagrams, case studies. Exercises.	1×3=3
4	Beyond elasticity: plasticity, yielding & ductility	Strength, plastic deformation work, ductility. Measurement. Charts. Study on parameters and features. Adjusting strength. Exercises.	1×3=3
5	Bend and crush: strength-limited design	Typical solutions to plastic problems. Indicators of plastic design - design for yielding, setting of boundaries and design indicators in diagrams, case studies. Exercises.	1×3=3
6	Fracture and toughness	Strength - toughness, basic principles of fracture mechanics. Measurement. Charts. Study on parameters and features. Adjusting and customization. Exercises.	1×3=3
7	Bend and crush: strength-limited design	Vibration and Resonance. Damping coefficient. Fatigue. Charts. Study on parameters and features. Adjusting and customization. Exercises.	1×3=3
8	Fracture-Limited Design	Typical solutions to fracture problems. Design indices - safe design against fracture, setting boundaries and design indices in diagrams, case studies. Exercises.	1×3=3

#	Title	Description	Hours
9	Materials and Heat	Basic thermal properties, material and property diagrams, Study on parameters and features that determine the thermal properties, Adjusting and customization of thermal properties. Design for utilization of thermal properties. Exercises.	1×3=3
10	Durability design	Wearing and degradation of materials. Oxidation, Flammability, Photo Degradation. Oxidation mechanisms. Resistance to wear. Corrosion, Study on mechanisms. Anti-corrosion protection, control methods. Exercises.	1×3=3
11	Sustainable Materials	Calculation of carbon footprint in the production of materials and their use (construction-operation-maintenance). Thermal behaviour and performance. Sustainability and design service life. Energy saving, waste recovery and recycling. Economic sustainability assessment. Compliance with the European Climate Change Directives.	1×3=3
12	Design and re-design project	Presentation of the project	2×3=6

Learning Objectives

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

- know the characteristics and parameters that determine the properties of the materials;
- know the production process, features and properties of advanced materials;
- Identify critical design properties of materials;
- distinguish the production and integration processes of materials in the construction that may limit their performance;
- calculate material design indices;
- know the parameters that characterize the sustainability of structures;
- calculate sustainability indicators of structures;
- understand the concepts and mechanisms of material wear;
- calculate theoretically critical values for the service life design.

Engineering Seismology

Course Description

The understanding of the seismic ground motion and the corresponding parameters, as well as the effects thereof on structural response. Determination of earthquake design parameters with deterministic and probabilistic models of the earthquake excitation.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Types and characteristic parameters of faults. Magnitude scales, relationships between magnitudes, empirical relationships between magnitude and fault characteristics.	1×4=4
2	Ground motion parameters	Networks and records of ground motion. Data bases and accelerograms. Parameters relating to the amplitude, duration, frequency and energy content of the records. Use of SEISMOSIGNAL software	1×4=4
3	Near field earthquakes	Directivity phenomenon. Directivity pulses and effects on the seismic response of structures.	1×4=4
4	Ground motion prediction models	Parameters and next generation ground motion prediction models: Boore-Atkinson, Chiou-Young, Cambell-Borzogna, Abrahamson-Silva. Attenuation laws for the region of Greece according to Theodoulidis, Skarladoudis, Ambraseys	2×4=8
5	Probabilistic analysis of earthquake hazard estimation	Guttenberg-Richter Law, Poisson distribution, Bounded Gutenberg-Richter recurrence Laws, Probability density function, Cumulative distribution function, Point, linear and surface sources. Seismic scenarios, regression analysis, estimation of average magnitude, distance and standard deviation.	3×4=12
6	Response spectrum	Conditional response spectrum with equal probability of exceedance. Code response spectra EC8, IBC etc.	1×4=4
7	Ground motion characteristics effects on structural response	Effects of characteristics of far field records (long duration) and near field records (directivity pulses) on the linear and non-linear response of single-degree-of-freedom oscillators.	1×4=4
8	Local soil conditions	Definitions, effect of local soil conditions on the ground motion, liquefaction.	1×4=4
9	Synthesis of time histories	Synthesis of artificial and semi-artificial accelerograms using the software SEISMOARTIF and SEISMOMATCH. Simulation of near field pulses, synthesis with high frequency spectral content, and synthesis of artificial near field records.	2×4=8

Learning Objectives

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

- recognize the parameters of the ground motion at a specific location;

- evaluate the frequency content of the motion;
- understand and assess the effects of the ground motion characteristics on structural response;
- select representative acceleration time histories based on the specific location and its seismicity for the dynamic analysis of structures and synthesize artificial records in case none are available;
- calculate the required response spectrum.

Engineering Law

Course Description

The aim of the course is to familiarize students with the basic concepts and the legislative framework governing the construction of any technical project and its impact on the environment.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction to modern technical law	Introduction and conceptual clarification of the concepts of modern technical law (Building Information Modelling-BIM, Blockchain, smart contracts-IT-Artificial Intelligence)	3
2	Property Valuation and Management, and Investment Management in urban development and planning	Real estate investment: planning, valuation and financing, property values, land management	3
3	Blockchain	Concept and typology of Blockchain, international and European applications of Blockchain technology in the fields of governance, economy and energy. Approaches to the impact of Blockchain technology on spatial planning issues-legal challenges.	3
4	Spatial Planning - Urban Planning - Environmental Law	Conceptual clarification of spatial and urban planning, levels and tools of spatial and urban planning, environmental licensing, EIA, AEPO, NATURA 2000 areas, forests, circular economy and their correlation with the concepts of technical law, Law 4759/20 and Law 4685/20.	2×3=6
5	From the General Building Regulation to the New Building	Structural work, building factor, coverage, building, building line, lot boundaries, load-bearing structure, arrangements for disabled or handicapped persons.	3

	Regulation. Basic definitions		
6	Building Regulation	Classification of buildings and structures based on use, safety and durability of buildings	3
7	Energy Performance of Buildings Regulation (KENAK)	Energy design in the building sector, improving the energy efficiency of buildings, energy saving and environmental protection.	3
8	Energy buildings	Planted roofs, roof construction regulations, planted roofs, structures and plantings in open spaces and fences.	3
9	Fire Safety Regulation	Relationship between Energy Performance of Buildings Regulation-Fire Safety Regulation- New Building Regulation.	3
10	The Greek contract and study management system	Historical background. Concepts and definitions. Contract award procedures and criteria. Registers of designers. Categories of studies and services. Commissioning, drafting and stages of studies. Specifications, regulations and fees for studies. MEC. MEC. Tendering and tendering procedures. Contractual documents. Construction supervision. Time limits. Penal clauses. Timetable. Calendar. Measurements. Accounts. Advances. Price review. Reductions of work. New work. Deficiencies. Contractor's discount. Termination of contract. Certificate of completion. Final Measurement. Provisional and final acceptance. Guarantee period. Final account. Dispute resolution.	3
11	Smart Contracts	Smart Contracts Applications, Public Works and Design Contract Management System	
12	Purchase of land and repair of a building	Divided property, horizontal and vertical. The system of consideration - Contractor. Establishment of horizontal properties. Regulation of the operation of a block of flats. Preliminary agreement and building purchase contract. Repair contractors' contracts. Insurance against risks	3

Learning Objectives

Upon successful completion of the course, students will be familiar with the basic concepts and the legislative framework governing:

- the construction of any technical project;
- the environmental licensing of projects;
- the issuing of building permits;
- the energy upgrading of buildings;
- the award of public works and design contracts;
- the management of public works and study contracts.

Sanitary Engineering

Course Description

This module consists of two parts; Part A and Part B. In part A water treatment for the production of drinking water is examined. Part A analyses the basic processes which take place in a water treatment plant. These consist of pre- and post-disinfection (chlorination, UV irradiation and ozonation), coagulation and flocculation, sedimentation and clari-flocculation (i.e. combined coagulation and sedimentation), sand filtration and sludge treatment through thickening and dewatering and sludge disposal. Furthermore, advanced methods for water treatment are examined. The students are required to carry out a basic design of a conventional water treatment plant following the principles which are described in class. Furthermore, the module consists of a laboratory exercise where the process of coagulation optimization is experimentally demonstrated. In part B, the basic processes which take place in wastewater treatment are analysed; these include pre-treatment, primary sedimentation, biological treatment and sewage sludge management. Part B of the module includes a series of exercises which the students should tackle.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction to water treatment	Physicochemical and microbiological parameters of water characterization, legislative framework for drinking water, usual technologies for water treatment, typical flow charts	1×4=4
2	Disinfection	Chlorination, UV irradiation, ozonation, pre- and post-disinfection, Design criteria, Examples	1×4=4
3	Coagulation, flocculation and sedimentation	Stability of colloids, mechanisms and parameters which affect colloidal stability, coagulation process, design of coagulation tanks for, settling theory, design of sedimentation tanks, clari-flocculation units, management of produced sludge, design parameters, examples	2×4=8
4	Filtration	Filtration mechanisms, characteristics of a filtration unit, design parameters, alternative operation modes, backwashing operation, examples	2×4=8
5	Advanced water treatment processes	Adsorption to activated carbon, ion exchange, electro-dialysis, microfiltration, ultrafiltration, nanofiltration, reverse osmosis, removal of hardness	1×4=4
6	Introduction to wastewater treatment	Wastewater characteristics, treatment requirements and relevant legislation, conventional wastewater treatment system, pre-treatment and primary treatment of wastewater	1×4=4

#	Title	Description	Hours
7	Biological wastewater treatment	Introduction to the activated sludge process for organic carbon removal and nitrification, design criteria for the aeration reactor, kinetics of organic carbon removal and biomass growth, factors affecting nitrification, development of mathematical model of activated sludge, design and operation of sedimentation tanks, Examples	4×4=16
8	Treatment valorisation and disposal of sludge	Sludge treatment processes, thickening of sludge, aerobic and anaerobic sludge treatment, dewatering, valorisation, final disposal, examples	1×4=4

Learning Objectives

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

- have a thorough understanding of the basic processes involved in water and wastewater treatment;
- solve a basic design of a water treatment plant;
- understand the usefulness and the importance of technologies and processes applied for water and wastewater treatment.

Hydraulic Structures & Dams

Course Description

The full set of knowledge required to design a dam at a preliminary design level. It encompasses the selection of the appropriate dam type, the siting and sizing of the basic technical elements during dam construction and the full set of hydraulic calculations for all hydraulic safety support structures (diversion tunnel, spillway, etc.).

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction, general layout of dams and related projects	Basic concepts. Historical context of dams. Implementation of dams. Failures. Examples. Types of dams. General provisions. Selection Criteria. Dam design principles. Stages of dam construction.	2×3=6
2	Earth dams, CFRD dams	General elements of earth dams. Types of earth dams. Basic design issues. Construction issues. Construction materials. Sealing of the core. CFRD dams. Membranes. Conservation storage reservoirs.	2×3=6

#	Title	Description	Hours
3	Concrete, RCC and hard fill dams	Gravity dams. Arch dams. Roller compacted concrete (RCC) and hard fill dams.	2×3=6
4	Reservoirs and dam hydrology	Siting criteria. Imperviousness of dam reservoir. Reservoir curves. Water balance. Study of reservoir operation. Drainage basin. Estimated inflows. Design flood hydrographs. Ecological flow. Reservoir sedimentation volume estimation.	2×3=6
5	Hydraulic design, flood management and flow management structures	Temporary diversion projects. Principles of hydraulic design. Flood management. Diversion systems. Bottom outlets. Spillways. Stilling basins.	2×3=6
6	Technology of dam operation	Water abstractions. Transport ducts. Computer-based support. Penstocks. Access Projects. Electromechanical works. Reservoir filling and rapid drawdown. Monitoring and maintenance. Dam safety.	1×3=3
7	Environmental and institutional issues	National and European context. Environmental Impact Assessment of dams. Life cycle of dams. Management of ecological flow. Reservoir sedimentation management.	1×3=3

Groundwater

Course Description

Introduction to groundwater and flow through porous media. Darcy's Law. Mathematical formulation of problems of flow through porous media. Analytical solutions for 1-D aquifers, confined, phreatic or leaky. Hydraulics of wells for steady and unsteady flow, multiple well systems, method of images, wells near boundaries. Subsoil and aquifer pollution. Geo-environmental pollution and soil. Physicochemical and biological pollutant-soil-water interaction processes. Contaminant speciation, contaminant fate and transport in the underground environment. Decontamination and remediation technologies in the geo-environment. Case studies.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Basic properties of groundwater aquifers. Groundwater balance. Darcy's Law.	4

#	Title	Description	Hours
2	Flow equations	Fundamental equations of a 3-D steady flow problem. Boundary conditions. Flow nets.	4
3	Hydraulic approach	Dupuit assumptions for a phreatic aquifer. Analytical solutions for 1-D confined and unconfined aquifers. Aquifers with a sloping bottom. Seepage through earth dams, Pavlosky's solution. Semi-permeable aquifers.	8
4	Application of complex functions theory in groundwater problems	Synoptic presentation of complex functions theory and of conformal mapping. Groundwater flow under impermeable structures. Kozeny's solution. Method of fragments.	4
5	Unsteady flow	Unsteady flow: Basic definitions, equations formulation.	4
6	Hydraulics of wells	Wells in steady and unsteady flow. Multiple well systems, wells near boundaries. Pumping tests.	12
7	Geoenvironmental pollution	Subsoil and aquifer pollution. Origin, categorization and legal-institutional context of pollution.	4
8	Fate and transport	Role of soil as a source of pollution and as a natural decontamination filter. Physicochemical and biological pollutant-soil-water interaction processes. Contaminant speciation, contaminant fate and transport in the underground environment.	4
9	Remediation technologies	Decontamination and remediation technologies in the geo environment. Case studies of geo-environmental pollution and restoration.	8

Computational Geotechnics

Course Description

Continuum Mechanics in Computational Geotechnics. Simple numerical methods: Slope stability and Stabilization with the method of slices. Introduction to the finite element and finite difference methods for the solution of boundary value problems in Geotechnical Engineering. Finite Difference Analysis of the nonlinear response of piles to lateral loading. Inverse analysis and optimization methods in the design of pile foundations. Constitutive models of soil behaviour. Application of the Finite Element method in engineering practice. Simulation of laboratory tests, bearing capacity and settlement of foundations, groundwater flow, deep excavations and retaining structures, tunnelling, static soil-structure interaction.

Semester: 8

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction: Numerical Methods in Geotechnical Engineering-Case Studies	The use of the finite element and finite difference methods in geotechnical engineering. Discussion of case studies.	4
2	Slope Stability and Stabilization with the Method of Slices	Numerical analysis of slope stability with the method of slices. The methods of Fellenius, Bishop and Janbu. Tutorial for use of dedicated PC software of slope stability analysis. Application examples involving dam slopes and road embankments. Probabilistic methods of analysis. Slope stabilization methods (e.g. piles, grouted anchors, retaining walls, embankments, dewatering etc.): Examples and analysis with the use of suitable software.	16
3	The Finite Difference Method: Application to Laterally Loaded Piles	The finite difference method for solving ordinary and nonlinear differential equations. Spreadsheet applications in the analysis of laterally loaded piles. Numerical methods for solving systems of nonlinear algebraic equations: The Euler, Newton-Raphson and Modified Newton-Raphson methods. Application to the lateral response of piles in nonlinear soil. Demonstration of multi-objective (serviceability and cost effective-based) optimization processes for pile-group design. Programming with MATLAB. Introduction to inverse methods of analysis for soil parameters identification.	16
4	Introduction to the Finite Element Method	Elements of the finite element method. Tutorial for use of the finite element code PLAXIS in geotechnical analysis and design. Numerical simulation techniques for solving boundary value problems.	4
5	Simple Constitutive Models of Soil Behaviour	Impact of soil constitutive modelling on the numerical analysis of geotechnical problems. Simple constitutive stress-strain relations for nonlinear soil behaviour (Mohr Coulomb, Duncan and Chang, Hardening Soil Model). Numerical modelling of laboratory load tests (triaxial and oedometer) focusing on the calibration of model parameters.	4
6	Numerical Modelling in Geotechnical Engineering	Applications of the finite element method in geotechnical engineering. Numerical analysis of (1) the excavation and temporary support of a metro station, (2) slope stability and (3) shield tunnelling.	16

Learning Objectives

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

- know the main limitations, advantages and field of application of the used numerical method of analysis;
- realize the capabilities of numerical modelling as a design Tool in geotechnical engineering;

- understand the necessity of using numerical methods for solving Geotechnical Engineering problems;
- develop and use simple numerical models;
- Analysing real case studies with the use of dedicated PC codes.

Computational Fluid Dynamics

Course Description

Introduction to Computational Fluid Dynamics (CFD), examples and CFD codes. Basic theory of CFD. Simple examples and CFD codes. The open source code OPENFOAM and applications. Flow around structures and other obstacles, e.g. flow around buildings, flow behind backward facing step, flow around bridge piers, flow around trees during flood events. Unsteady flow in pipes. Water hammer and its application. Hydraulic Ram.

Semester: 8

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduction. Practical importance and applications of the CFD models.	1×3=3
2	Development of theory of Computational Fluid Dynamics	Presentation of the basic theory of CFD. Basic hydrodynamic and scalar transport equations; from their 3D to the simple 1D formulation. Solution of the 1D advection-diffusion equation with the method of finite volume. Discretization schemes (upwind, central and LAX). Explicit and implicit solution. Tutorial 1.	2×3=6
3	Codes of Computational Fluid Dynamics	Characteristics and capacities of OPENFOAM. Introduction and setting. Brief presentation of simple applications.	2×3=6
4	Applications - case studies	Case 1. Flow behind an obstacle - Backward facing step. Turbulence models. Tutorial 2. Case 2. Flow around a cylinder. Flow instabilities. Tutorial 3. Case 3. Flow near roofs and around photovoltaic panels. Pressure distribution. Presentation and discussion of real flow cases around structures.	6×3=18
5	Nonsteady flow in pipes - Hydraulic hammer	Calculation of overpressure in a hydraulic ram using the method of characteristics. Comparison of the calculations with experiments performed in the Laboratory of Applied Hydraulics. Tutorial 4.	2×3=6

Learning Objectives

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

- Understand and explain the main principles of CFD;
- Understand the main characteristics of a CFD code;
- Conceptualize the main principles of CFD modelling and have knowledge on practical cases using CFD modelling;
- Utilize their hands-on experience in the step-by-step modelling procedure to build simple models EXCEL, MATLAB or FORTRAN.
- Familiarize with the open source code OPENFOAM and use it to develop and solve CFD problems.

4.9 9 th Semester

Soil-Structure Interaction

Course Description

The concept of soil-foundation-structure interaction. Examples of applications to foundations, retaining systems and underground structures. Stiffness matrix for rigid foundations on elastic continuum. Analysis of case studies emphasizing on soil-structure interaction: The Rion-Antirion bridge. Foundation response to combined axial and lateral loading: From quasi elastic behaviour to uplifting and bearing capacity failure. Nonlinear methods for evaluating the seismic performance of SSI systems. Analysis of single piles subjected to axial and lateral loading. Analysis of pile-groups considering pile-to-pile interaction. Seismic kinematic and inertial soil-pile interaction. Case histories focusing on SSI: (1) The collapse of Fukae bridge in Kobe 1995 earthquake, and (2) the leaning tower of Pi.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction: The role of Soil – Structure Interaction (SSI)	How Soil-Structure Interaction affect the design of civil engineering structures (e.g. high rise building, bridges, underground structures etc.) and the design of their foundation. Examples from real projects.	1×4=4
2	Stiffness of a Rigid Foundation in Elastic Soil	Determination of the stiffness matrix for soil-structure interaction systems (shallow and embedded footings, caisson foundations). Methods for calculating the stiffness matrix: Rigorous Analysis: The theory of elasticity, Numerical Analysis: The finite element method, Simplified physically motivated analysis. Characteristic solution in the form of closed analytical expressions for the foundation stiffness matrix,	2×4=8

		accounting for soil layering, inhomogeneity, foundation shape and embedment effects. Numerical Analysis with the use of the F.E code PLAXIS.	
3	Analysis of Case Studies emphasizing on Soil-Structure Interaction	Analysis of a laterally loaded single-span frame structure with and without considering soil-structure interaction effects. Examples from large-scale projects: Analysis of the foundations of the Rion-Antirion Bridge. Seismic Soil-Foundation-Superstructure Interaction Analysis.	1×4=4
4	Foundation Response Analysis: From quasi elastic behaviour to foundation uplifting and bearing capacity failure	Failure mechanisms of shallow and embedded foundations subjected to combined axial and lateral loading. The meaning of progressive failure in bearing capacity problems. Non-linear Soil-Foundation-Superstructure Interaction Analysis. Numerical Analysis with the use of the F.E code PLAXIS	2×4=8
5	A Nonlinear Method for Evaluation the Seismic Performance of SSI Systems	The concepts of generalized factor of safety and secant (effective) foundation stiffness matrix. Extending the N2 method to account for SSI effects. Application to case studies with the use of the FE code PLAXIS.	3×4=8
6	Analysis of Single Piles under Lateral and Axial Loading	Determination of the stiffness matrix for piles in elastic soil. Laterally loaded flexible and rigid piles. Non-linear horizontal soil reaction on piles: The concept of p-y curves.	1×4=4
7	Analysis of Pile Groups considering Pile–to–Pile Interaction	Group of piles under lateral and axial loading. Pile-to-pile interaction and group efficiency: Static and dynamic loading.	1×4=4
8	Seismic Kinematic Soil-Pile Interaction	Kinematic and Inertial response of piles. Method of analysis. Group effects. Examples, Case histories.	1×4=4
9	Case Histories of failure and Forensic SSI Analysis	The collapse of Fukae bridge in Kobe 1995 earthquake. The leaning Tower of Pisa.	1×4=4

Learning Objectives

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

- know the role of Soil-structure interaction (SSI) on the performance of civil engineering structures, and its influence on the foundation design;
- realize the capabilities of numerical modelling as a design Tool in solving SSI problems;
- understand the necessity of characterizing the role of SSI for the safe design of earthquake resistant structures;
- develop and use simple numerical models;
- analysing real case studies with the use of dedicated PC codes.

Seismic Retrofit and Strengthening of Existing Structures

Course Description

The course covers theory and case studies on assessment, repair, and strengthening of existing structures (of RC mainly) subjected to seismic actions. After successful accomplishment, students will be able to specify the bearing capacity of existing structures against earthquakes; also to design possible required interventions for the upgrade of the safety level in accordance to regulations' provisions.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Significance, specifications, principles and procedures for structural assessment and strengthening.	1×3=3
2	Nonlinear analysis for reinforced concrete members	Cross-sectional analysis for reinforced concrete members, limit states, chord-rotation.	1×3=3
3	Nonlinear Static Analysis	Response spectra, capacity curve, target displacement, control node.	1×3=3
4	Strengthening techniques	Description of techniques and interventions.	1×3=3
5	FRPs	Properties of composite materials and applications.	1×3=3
6	Loading Phases	Influence of loading phases to internal forces and stresses.	1×3=3
7	Force Paths/ dowel connectors	Anchor and dowel interface action at interfaces between existing members and additional reinforcement.	1×3=3
8	Behaviour of structural elements	Description and assessment of earthquake damage. Methods of intervention and rehabilitation. Idealized force-displacement curves.	1×3=3
9	Strengthening of isolated members	Case Studies, with the use of: (a) jacketing, (b)metallic lamellae, (c) FRP fabrics.	3×3=9
10	Influence of infills and walls	General concept, case studies.	1×3=3

Learning Objectives

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

- master the principles and the regulative norms for the specification of the bearing capacity and redesign of existing structures;

- evaluate strengthening interventions (including calculations, drawings, detailing etc.) under new prescribed actions.

Earthquake Engineering II

Course Description

In depth understanding of earthquake engineering concepts. Advanced topics: base isolation, reliability assessment, soil-structure interaction.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Seismic design of spatial frames	Modal response spectrum analysis (recap) - Combination of extreme values of interaction load effects - Load combinations, Diaphragm action, principal axes, torsionally sensitive systems, Accidental eccentricity	3×4=12
2	Special EC8 provisions	Seismic design of Multi-degree-of-freedom systems - Capacity design - Primary and Secondary seismic members	1×4=4
3	Seismic response of special structures	Systems with distributed mass and elasticity, masonry buildings.	1×0.5=2
4	Response history analysis	Selection and use of ground motion records for seismic design and assessment	1×0.5=2
5	Non-linear Static Analysis (Pushover)	Equivalent single-degree-of-freedom-system. Member capacity curve, Building capacity curve, target displacement, the N2 method, the displacement coefficient methods, introduction to performance-based design.	3×4=12
6	Vulnerability analysis	The concept, empirical curves, calculation methods.	1×4=4
7	Base isolation	Examples of base isolation, types of isolators/bearings, analysis/assessment methods, design code checks.	3×4=12
8	Soil-structure interaction	Fundamentals, modelling, modification of the period of the damping properties.	1×4=4

Learning Objectives

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

- seismically design a building to the seismic code;

- apply the performance-based design philosophy;
- seismically design a structure using nonlinear analysis methods;
- understand the fundamentals of seismic reliability analysis through fragility curves;
- design structures considering soil-structure interaction.

Bridge design II

Course Description

Selection of bridge type, design and calculation of superstructures - infrastructures of reinforced concrete bridges. Contemporary construction methods and earthquake resistant design. Systems for bridging large spans - Special issues on repair and retrofitting of bridges.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Examples of application of actions and calculation of superstructure and piers response. Brief presentation of basic pre-tensioning concepts.	3×2=6
2	Superstructure	Design Criteria and Type Selection. Supporting systems. Simulation instructions. Methods of analysis of characteristic types (Beams - Slabs - Girders). Influence of the method and the construction stages in the calculation of the response.	3×4=12
3	Pier and retaining systems	Abutments, Piers and retaining walls	1×4=4
4	Mechanized construction methods	Pre-casting beams. Balanced Cantilever method. Incremental Launching Movable Scaffolding System. Span by span segmental.	3×4=12
5	Methods of bridging large spans	Cable, lifted and arch-type bridges	1×4=4
6	Earthquake resistant design	Design methods. Assessment of the seismic actions. Seismic isolation	3×4=12
7	Special Issues	Repair - retrofitting	1×2=2

Learning Objectives

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

- recognize the design principles of bridge superstructure, infrastructure and foundation;

- select the type and design reinforced concrete bridges;
- determine the loads of highway bridges according to Eurocodes;
- know modern construction methods;
- perform the preliminary design of simple bridges.

Traffic Management and Road Safety

Course Description

Traffic Management and Road Safety is part of 9th semester courses. It is compulsory for the students at the Transportation Planning and Engineering cycle. The course includes basic definitions of traffic management (management of traffic flow, vehicles' traffic restrictions, peak hours traffic reduction, preferential treatment of high occupancy vehicles, pedestrian traffic, bicycles traffic, advanced driver-assistance systems, autonomous vehicles) and road safety (data collection and analysis, correlation of accidents with road environment, correlation of accidents with user and vehicle characteristics, identification of high risk sites, analysis of high risk sites locations and related countermeasures, evaluation of countermeasures). The course also includes traffic counts by the students. The course foresees four hours of theory and exercises every week. During the exercises practical examples of applications are developed and in general the overall understanding of the course is assisted. It should be also noted that there is no clear distinction between theory and exercises, since the theory relies on exercises and exercises deal with questions about the theory. Students consist of one class.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Definitions Traffic Management Road Safety	1×4=4
2	Traffic Management	Management of traffic flow Vehicles' traffic restrictions Peak hours traffic reduction Preferential treatment of high occupancy vehicles Pedestrians traffic Bicycles traffic Advanced driver-assistance systems Autonomous vehicles	6×4=24
3	Road Safety	Data collection and analysis Correlation of accidents with road environment Correlation of accidents with user and vehicle characteristics Identification of high risk sites Analysis of high risk sites and related countermeasures Evaluation of countermeasures	6×4=24

Learning Objectives

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

- learn the basic definitions and parameters of traffic management and road safety;

- realise the advantages and measures of vehicle and pedestrian traffic management and policies for parking management;
- understand the importance of collecting and analysing data to identify and analyse high risk sites and their safety problems and assess relevant countermeasures;
- emphasize the effect of several factors (driver, road infrastructure, vehicle) on road accidents.

Water Resources Management

Course Description

The aim of the course is to introduce students to the basic principles of water resources management, and to explore the key concepts, methods and tools that support their design and optimal operation under uncertainty. Particular emphasis is given to reservoir design and modelling, uncertainty analysis, multi-criteria decision making, game theory and single/multiobjective optimization.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Key definitions (hydrosystem, water resource systems analysis, water resource management, supply & demand), water resource management objectives. Legal Framework (WFD).	1×4=4
2	Supply: Hydrological Design of Hydrosystems	Reservoirs and Aqueducts. Dimensioning and Design methods: Conventional, stochastic, dimensioning with simulation, dimensioning of a reservoir in a river without measurements.	3×4=12
3	Demand: Assessment and Management of Water Demand	Basic demands (rural, urban). Demand vs needs. Rural development and best irrigation practices in agriculture. Urban development and management of urban water demand. A ‘hidden’ demand: ecological flow.	2×4=4
4	Matching Demand to Supply: Uncertainty and tools to manage it.	Assess and manage uncertainty at different scales. Stochastic models, Socio-economic scenarios, Simulation techniques. Sensitive Analysis. Monte-Carlo method. The Latin Hypercube variant.	1×4=4
5	Multi-purpose hydrosystems: part 1 – top down.	The fundamental water resource management problems. Building a model. Occam’s razor. Simulation and optimization as one. Dealing with multiple objectives. The idea of Pareto.	2×4=8

#	Title	Description	Hours
6	Multi-purpose hydrosystems: part 2 – bottom-up.	Introduction to Game Theory. Tragedy of the Commons (with an application to groundwater management). One-off and recurrent games. A different kind of game: Water Monopolies.	1×4=4
7	Optimization in Water Resources Management: conventional methods.	Analytical methods, Hill-climbing methods, Dynamic Programming, Linear programming. With examples from water allocation problems.	1×4=4
8	Optimization in Water Resources Management: advanced methods.	Genetic algorithms, Evolutionary programming, Simulated Annealing.	1×4=4
9	Economics in Water Resources Management	Basic concepts of economic theory. Water as an economic resource. Determining the full economic cost of water.	1×4=4

Learning Objectives

[Missing information in the English transcript]

Wastewater Treatment and Disposal Plants

Course Description

In this module the detailed design of a municipal wastewater treatment plant is realized. This includes the sanitary engineering calculations, the hydraulic study, the technical choices that should be made and the overall plant layout. The design includes the dimensioning of the pre-treatment works, the primary sedimentation, the biological treatment, the tertiary treatment works and the management and treatment of sludge through thickening, anaerobic digestion and dewatering. Furthermore, some special topics are covered such as the design of the aeration system, the management and valorisation of biogas and automation works. Finally, this module covers membrane bioreactors and attached growth processes applied for municipal wastewater treatment and how operating problems are confronted.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction to water treatment	Brief revision of the basic processes involved in the treatment, disposal and reuse of wastewater and sludge with reference to	1×4=4

#	Title	Description	Hours
		the relevant legislation. Quantitative and qualitative characterization of sewage, description of the stages involved in the works concerning the construction and disposal of municipal wastewater.	
2	Activated sludge process with nutrient removal	Activated sludge process with nutrient removal, nitrification/denitrification, biological and chemical phosphorus removal, kinetics, stoichiometry, design principles.	2×4=8
3	Design of wastewater pre-treatment and primary treatment works	Design of pre-treatment works (initial pumping, inlet works, mechanical screening, aerated sand removal, oil and grease removal and flow measurement) and of primary treatment (circular and rectangular sedimentation tanks), management of the by-products of the pre-treatment works (screenings, sand, oil and grease). Mass balances, equipment automation, examples solved in class	1,5×4=6
4	Design of biological treatment works	Design of the activated sludge process for the removal of organic carbon, nitrogen and phosphorus. Determination of kinetics and solids retention time, excess sludge and sludge recycle as well as of the mixed liquor suspended solids. Mass balance of nitrogen and phosphorus. Design of the unit for chemical phosphorus removal. Design of the final sedimentation tanks and of the pumping station of excel sludge and sludge recycle. Equipment automation, examples solved in class	2,5×4=10
5	Tertiary treatment works – disinfection and disposal works. Reclaimed water reuse and relevant legislation	Tertiary treatment of sewage (sand filters, membranes, advanced processes). Disinfection systems (chlorination, UV irradiation, ozonation). Works for the discharge of the treated effluent (discharge pipe, diffusers). Legislative framework regarding the reclaimed water reuse.	1×4=4
6	Design of sludge treatment and biogas management works; sewage sludge sanitization and potential reuse of sludge	Design of sludge thickening works (mechanical and gravity thickening), anaerobic digestion (mixing and heating of digester, geometric characteristics), dewatering (drying beds, mechanical thickening). Mass balances. Energy – thermal balances for the anaerobic digestion unit. Introduction to the management and valorisation of biogas (biogas storage, combined heat and power units, boilers). Sludge sanitization and use. Equipment automation, examples solved in class.	2×4=8
7	Basic principles of hydraulic calculations and layout of the works	Basic principles of the layout of wastewater and sludge treatment units. Auxiliary works (buildings, management of sludge reject water, rainwater, industrial water and drainage), road	1×4=4

#	Title	Description	Hours
		construction, landscape formulation. Hydraulic design of works. Development of the geometry of tanks and pumping stations.	
8	Design of aeration system for the aeration tank	Basic principles of aeration systems design (diffuse aeration, surface aeration). Calculation of blowers and diffusers. Calculation of energy requirements of aeration systems. Basic principles for the reduction of energy consumption. Equipment automation, examples solved in class.	1×4=4
9	Membrane bioreactors and attached growth processes	Basic principles of membrane bioreactors (MBRs); Attached growth processes; Basic design principles	1×4=4

Learning Objectives

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

- calculate and dimension all the stages of a wastewater treatment plant;
- calculate the hydraulic profile of the wastewater treatment works;
- dimension the basic electromechanical equipment and make technical choices;
- participate in the design of works related to the valorisation of biogas;
- understand issues concerning automation in a wastewater treatment plant;
- tackle basic operational problems in a wastewater treatment plant.

Soil Dynamics

Course Description

Introduction: problems and significance of soil dynamics. Dynamics of simple (mass-spring-dashpot) systems under base excitation. Concept and applications of response spectrum for the seismic design of structures. One-dimensional wave propagation, reflection and refraction, propagating and stationary waves. Two-dimensional wave propagation, Rayleigh and Love waves. Soil behaviour under dynamic and cyclic loading, for small, medium and large cyclic strains. Measurements of seismic soil parameters in the laboratory and in situ. Constitutive models for the simulation of the visco-elastic cyclic soil response. Analytical and numerical seismic response analysis of soil sites (“soil amplification” of seismic motion). Liquefaction of saturated granular soils: evaluation of liquefaction potential, assessment of liquefaction effects on engineering structures, methods for liquefaction mitigation.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Problems and significance of Soil Dynamics. Course organization.	0.5×4=2
2	Dynamics of 1DOF systems under base excitation	Dynamic response of 1DOF systems under harmonic base excitation, Elastic Response spectra.	1.5×4=6
3	1D wave propagation in soils	P & S wave propagation equation, refraction & reflection phenomena.	2×4=8
4	3D wave propagation in soils	Refraction and reflection of P & S waves at interfaces, Snell's Law, Rayleigh and Love waves.	1×4=4
5	Cyclic soil response	Shear modulus & hysteretic damping degradation, permanent strain accumulation & excess pore pressure build up due to cyclic loading.	2×4=8
6	Measurement of seismic soil parameters	Laboratory & in situ measurement of seismic soil properties for small-medium-large cyclic strains. Student training in the execution and interpretation of Crosshole and Downhole tests.	2×4=8
7	Seismic ground response ("soil amplification")	Analytical and numerical analysis of seismic ground response with the frequency domain (equivalent linear) and the time domain (non-linear) methods. Term project for a typical site and bridge foundation.	2×4=4
8	Earthquake-induced soil liquefaction	Methods of liquefaction potential evaluation. Liquefaction induced soil settlements, shear strength degradation, lateral ground spreading. Ground improvement methods to mitigate liquefaction effects.	2×4=4

Learning Objectives

Upon successful completion of the course, students will be:

- familiarized with the peculiarities and the requirements of Soil Dynamics and Geotechnical Earthquake Engineering projects, as well as with the experimental methodologies required to obtain the necessary dynamic soil properties;
- trained in state-of-the art analytical and numerical methods for assessing: (a) soil effects on seismic ground motions and design response spectra, and (b) liquefaction effects on engineering structures and design of required special construction measures.

Selected Topics in Foundation Engineering

Course Description

Flexible retaining walls and anchors: General overview. Computation of earth pressures for cohesive and cohesionless soils, under various drainage and flow conditions. Design of self-supported flexible walls (without anchors). Design of flexible walls with a single anchor at the top or multiple anchors along the height. Construction and design methods for anchors. Evaluation of the overall stability of the wall-anchor-soil system. Computer aided application in design practice.

Soil improvement and reinforcement: General review of available methods. Soil improvement by pre-loading. Strength and compressibility of the improved ground for different cases of applied preloading. Design of drains to accelerate excess pore pressure dissipation and reduce the required preloading period. Soil reinforcement using gravel piles. Construction methods. Bearing capacity and settlements of single gravel piles and groups of gravel piles. Shear strength parameters of "equivalent uniform" of gravel pile improved soil layers. o Field exercises: Visits of relevant construction sites within the Greater Athens area and a (2-3 day) trip to major construction sites all over Greece.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	The presentation of the contents and the objectives of the course follows a brief selective review of the basic knowledge required for the teaching of individual subjects. In particular, emphasis is given to the theory of earth pressures under drained and undrained (from Soil Mechanics I), steady state water flow through the pores, as well as permanent water flow and soil consolidation theory (from Soil Mechanics II)	2×4=8
2	Flexible Retaining Structures	The theory of earth pressure computation is applied to the case of flexible retaining walls without anchors (cantilevers) as well as with a single anchor or multiple anchors. The cases of retaining walls in sand and in clay are examined separately, with emphasis on undrained (short term) and drained (long term) stability issues.	4×4=16
3	Anchors	The practice of anchor construction is initially presented practice, and the design methodology follows. The following failure modes are considered: anchor pullout, wedge failure, global slope stability failure and composite failure Kranz.	2×4=8
4	Ground Improvement & Reinforcement	The different ground improvement and reinforcement methods applied in practice are initially reviewed. In the sequel teaching focusses upon three of these methods which are most common in geotechnical construction: (a) Pre-loading of weak clay deposits to increase the bearing capacity and reduce settlements, (b) Use of drains to accelerate the excess pore water	5×4=20

#	Title	Description	Hours
		pressure dissipation and reduce the required preloading time, and (c) Use of gravel piles, combined with vibro-compaction or vibro-floatation, in order to increase the shear strength and reduce the compressibility of weak soil layers bearing surface foundations and embankments.	

Learning Objectives

Successful completion of the course requirements will enable students design and supervise construction of:

- flexible retaining walls for deep excavations;
- anchors for the support of flexible retaining walls rock slopes;
- preloading works for clayey soils;
- plastic and sand drain networks;
- group of gravel piles for the enhanced foundation stability and settlement of buildings, embankments, etc.

Advanced Topics in Port Engineering

Course Description

The course aims to provide students with specialized knowledge about the design and operation of ports. The port development study is a complex process requiring a multidisciplinary approximation approach that takes place within this course of the subject of the specialty of Civil Engineer who is responsible for the conception and design of the relevant works. Particular emphasis is given to the organization of the terrestrial space and to the modern methods design of port projects.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction		1×3=3
2	Port-level design	Design of Port Development, Port Design Principles, Flow Forecasting, Port Productivity, Master Plan, Inland Connections, Maintenance and Equipment Design of Port Projects using Computational Programs, Visit to Port of Lavrion.	3×3=9
3	Port stations	Phases of Port development, General cargo port station, Port container terminal: General guidelines, cargo handling, stacking yards, RoRo	5×3=15

#	Title	Description	Hours
		terminal, Port station of multiple use, Port Stations of Liquid - Bulk Cargo, Marinas - Fishing Shelters and Small Harbours.	
4	Design of Port Structures using modern methods	Tranquillity of harbour basins: calculation of disturbances due to wind waves, overtopping of structures, port down-time, seiches. Probabilistic design of port structures. Environmental impacts of port developments.	4×4=16

Learning Objectives

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

- recognize the main categories and characteristics of all port stations;
- understand the usefulness of modern stochastic methods and computational programs in port design;
- design the general layout of a port and its inland connections;
- calculate the individual parts of a port by using the relevant codes, and control the safety of its operation;
- assess the environmental impact of the port construction and operation phase.

Advanced Topics on Pavements

Course Description

Students will get familiar with the quality control procedures for materials and mixtures in the laboratory and on site, in terms of quality assurance of the construction. Participation in experimental applications in the laboratory and on site, with the advanced systems of the Laboratory of Highway (and Pavement) Engineering.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction - Basic principles of quality control - Laboratory	Basic definitions. Importance of quality control of materials used in pavements and of tests used to ensure the quality of the construction of the individual pavement layers, in terms of pavement delivery. Laboratory Accreditation Issues - ISO 9001.	1×4=4
2	Quality control of aggregates, unbound materials and asphalt in the laboratory	Basic characteristics of the unbound materials and the components of asphalt mixtures (aggregates and asphalt), in accordance with the applicable legislation and European Norms (CEN). Laboratory applications to familiarize students with testing. Performing testing in the laboratory by student groups with the appropriate guidance.	3×4=12

#	Title	Description	Hours
		Analysis of laboratory data and evaluation of results in class. Comprehension exercises in class.	
3	Quality controls of asphalt mixtures in the laboratory	Processes of asphalt mix design. Required tests for asphalt mixes properties (volumetric and mechanical), in accordance with the applicable legislation and European Norms (CEN). Laboratory applications to familiarize students with testing. Analysis of laboratory data and evaluation of results in class. Comprehension exercises in class.	5×4=20
4	Quality assurance issues –Laboratory – In-situ testing	Basic construction processes and recommendations for the integrity of construction. Quality control tests, using conventional methods and Non Destructive Testing, in terms of pavement delivery procedures and monitoring. Applications for familiarizing students with on-site testing with modern Systems of the Laboratory of Highway (and Pavement) Engineering. Presentation and discussion of case studies. Comprehension exercises in class, as well as homework, combined with oral examination.	4×4=16

Learning Objectives

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

- be familiar with the main quality control tests on pavement materials;
- deepen on laboratory testing and on field testing;
- analyse and evaluate the results of quality controls;
- understand the usefulness of testing in terms of quality assurance of pavement construction.

Advanced Topics in Reinforced Concrete

Course Description

Special topics on the design of reinforced concrete works are being covered, which, due to time limitations, are not covered in the core courses' syllabus.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Accidental actions (seismic and impact)	Seismic damages. Ductile and brittle fractures. Earthquake design principles	1×4=4

#	Title	Description	Hours
2	Accidental actions (seismic and impact)	Nonlinear behaviour of RC members. Local and general ductility. Material and section ductility. OpenSees freeware. Push-over analysis.	3×4=12
3	Accidental actions (seismic and impact)	Non-linear analysis of slabs. Yield line theory. Johansen's criteria.	2×4=8
4	Accidental actions (seismic and impact)	Design under impact actions. Design spectra for beam and slab analysis.	1×4=4
5	Accidental actions (seismic and impact)	Analysis and design of large lightly reinforced concrete walls	1×4=4
6	Fire design	Strength and deformation properties of materials at elevated temperatures. Calculation methods. Member verification under fire. Minimum cover and code provisions. Fire analysis with the OpenSees freeware.	3×4=12
7	Early age behaviour of concrete	Early age cracking of concrete and design for the crack width limitation in SLS. Liquid retaining structures.	2×4=8

Learning Objectives

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

- understand the behaviour and design concrete structures under accidental actions such as impact actions and fire;
- understand the early age behaviour of concrete, non-linear RC slab analysis;
- design of large lightly reinforced concrete walls.

Plates & Shells - Special Issues in Finite Element Analysis

Course Description

The first part of the course aims at understanding the behaviour of the plate, which is a basic structural element in the civil engineering. The plate equation is derived and several plate problems are solved. In the second part, finite elements (FE) used for plate analysis are presented. A simple introduction to the theory of shells is then given. Static behaviour of cylindrical and axisymmetric shells as well as their numerical simulation through FE is attempted next. The discretization error in the FE method and ways to handle it are then discussed. Finally mixed types of FEs are presented.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction to mathematical theory of elasticity	Elements of theory of elasticity. Stress, displacements and strains. Constitutive equations, equations of equilibrium, compatibility equations of strains.	4
2	Thin plates	Thin plates with small deflections. Basic Kirchhoff theory assumptions. Bending surface and its geometrical properties.	4
3	Differential equation of the plate	Stress resultants. Differential equation of the plate and boundary support conditions for straight and curvilinear boundaries.	6
4	Rectangular plates	Rectangular plates. Analytical and approximate methods for solving thin plates with small deflections.	3
5	Circular plates	Plate equation and stress resultants in polar coordinates. Circular and annular plates under axisymmetric and arbitrary loading.	3
6	Thick plates	Shear effect on plate behaviour.	4
7	Recalling general features of the finite element method.	Principles of discretization. Different finite element (FE) types and fields of their application. Discretization and numerical errors.	4
8	Finite elements for plate analysis (Kirchhoff)	Boundary conditions. 4-noded rectangular plate elements. Patch test. 6-noded triangular FE with 6 degrees of freedom	4
9	Finite elements for plate analysis (Mindlin)	Rectangular isoparametric Reissner-Mindlin plate elements. Shear locking. Selective and reduced integration. Triangular plate element with selective application of the Reissner-Mindlin theory. Isoparametric Timoshenko beam element.	2×3=6
10	Shells. Cylindrical and axisymmetric shells.	Introduction to the theory of shells. Membrane and bending behaviour. Analytical and numerical treatment by FEs of cylindrical and axisymmetric shells under axisymmetric loading.	2×4=8
11	Modelling of surface structures	Modelling of a real surface structure using a FE program. (e. g. modelling of a bridge, cylindrical shell roof, etc.)	2
12	Adaptive Finite Elements	A priori error estimate. H and p refinement. Hierarchical FEs.	2
13	Mixed type elements	Mixed type elements	2

Learning Objectives

The first part of the course aims at understanding the behaviour of the plate, which is a basic structural element in the civil engineering. The plate equation is derived and several plate problems are solved. In the second part, finite elements (FE) used for plate analysis are presented. A simple introduction to the theory of shells is then given. Static behaviour of cylindrical and axisymmetric shells as well as their numerical simulation through FE is attempted next. The discretization error in the FE method and ways to handle it are then discussed. Finally mixed types of FEs are presented.

Off-shore Structures

Course Description

Introduction to hydro-dynamics affecting off-shore structures and underwater pipelines. Loads on thin cylindrical elements due to wave action. Morrison's formula for vertical and inclined elements. Mooring systems and loadings due to wave action and operational loads. The hydrostatic stability of floating structures. Underwater pipelines.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	First order wave theory for monochromatic waves. Formulation of the interaction problem on sea waves and solid objects. Solution for specific cases - Application Examples.	1×3=3
2	Morrison's equation for vertical and inclined elements	Hydrodynamic loads on cylindrical members of small diameter and on large bodies	3×3=9
3	Mooring systems	Static and dynamic analysis of mooring lines/cables	3×3=9
4	The hydrostatic stability of floating structures	Hydrostatic stability. Definition of floating device failure.	2×3=6
5	Underwater pipelines	Estimation of hydro-dynamic loads. The stability of underwater pipelines. Recommendations on the design and lying of undersea pipelines.	4×3=12

Learning Objectives

Upon successful completion of the course, students will be able to solve complex problems related to the calculation of hydrodynamic loads on:

- marine offshore structures;
- mooring systems submarines;
- floating structures;
- underwater pipelines.

Analysis Methods in Traffic Engineering

Course Description

The aim of the course is to introduce students to advanced concepts of traffic flow models development within the framework of Intelligent traffic control systems. The course includes topics such as computer based and telematics traffic control systems, analysis standards for traffic junctions, urban corridors and networks, traffic simulation standards and their applications, queuing theory, traffic capacity in areas of traffic streams merging, traffic flow analysis, short-term traffic flow prediction, machine learning for traffic forecasting. Applications are developed in WEKA open source software and traffic simulation environment. The weekly program includes 4 teaching hours of theory and applications. During lecture time applications and exercises are solved and no clear distinction between theory and exercises exists. The course includes 4 mandatory exercises and 1 oral examination.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Intelligent Transportation Systems	Introduction. Traffic control systems. Processes and patterns. Microscopic and macroscopic traffic analysis. Traffic forecasting.	2×4=8
2	Advanced traffic flow patterns	Hydrodynamic models. Car-following models. Cellular automata. Traffic merging models in freeways. Applications.	3×4=12
3	Queuing theory	Basic principles. Queue and delay computations. Main characteristics of a queuing system. Types of queues. Single and multiple channel queuing systems. Queuing theory applications in traffic flow.	2×4=8
4	Traffic simulation	Basic principles. Simulation standards. Optimization of signalization. Traffic simulation in urban networks. Applications.	3×4=12
5	Machine learning	Machine learning principals. Introduction to open source machine learning software WEKA. Machine learning applications for traffic engineering (classification and forecasting).	3×4=12

Learning Objectives

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

- know the principal categories of analysis methods and simulation applied in traffic engineering;
- realize the influence of analytical methods on modern intelligent traffic control and management systems;
- understand the importance of open source software and programming in resolving traffic problems;
- develop codes to implement patterns for solving traffic flow problems;

- assess traffic models based on their usefulness and reliability.

Nonlinear Behaviour of Steel Structures

Course Description

Objective of this course is to enable students to understand the fundamental concepts of nonlinear behaviour of metal structures and its consequences on the choice of appropriate methods of structural analysis and design. Geometric and material nonlinearities and their interaction are covered, as well as influence of initial imperfections. Through the course a better understanding of the theoretical background of steel structures design rules is achieved, and the necessary abilities are developed in order to carry out numerical calculations for obtaining the ultimate strength of unconventional steel members and structures, which are not covered by the pertinent codes.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Objectives and organization of the course, prerequisites of linear behaviour, fundamental concepts of nonlinear behaviour, types of nonlinear behaviour, material nonlinearity, geometric nonlinearity, interaction between nonlinearities, influence of imperfections, examples of nonlinear behaviour, (compressed cylindrical shell, simply-supported compressed bar, triangular von Mises truss, triangular truss apse), overview of types of nonlinear behaviour, importance of imperfections and types of analysis.	2×3=6
2	Material nonlinearity	Constitutive behaviour of steel (actual and idealized), failure criteria under combined stress field, elastic-plastic behaviour of cross-sections in bending, the concept of plastic hinge, elastic-plastic behaviour of cross-sections in bending and axial force, elastic-plastic behaviour of cross-sections in bending and shear force, elastic-plastic behaviour of simply-supported beam, clamped beam, 2-span continuous beam, simply-supported frame, clamped frame.	1×3=3
3	Geometric nonlinearity – 1DOF systems	Concept of geometric nonlinearity, linear and nonlinear buckling theory, equilibrium or Euler method, energy method (equilibrium and stability theorems), dynamic method (phase diagrams, bounded and unbounded motion, relation between eigenfrequencies and stability, influence of initial conditions, influence of damping), examples of perfect and imperfect 1-DOF systems failing via a symmetric stable, symmetric unstable o asymmetric bifurcation point or via a limit point,	2×3=6

#	Title	Description	Hours
		recommended analysis methods, influence of initial imperfections, correlation of 1DOF models with actual structural systems.	
4	Geometric nonlinearity – MDOF systems	Equilibrium or Euler method, energy method, dynamic method, linear and nonlinear buckling theory, buckling modes, shape and size of initial imperfections, buckling mode interaction, influence of ratio between critical buckling loads and imperfection amplitudes on the nonlinear response.	
5	Numerical solution of nonlinear problems	Features of the finite element method for nonlinear problems, solution algorithms of the resulting system of nonlinear equations, step-wise load incrementation, full and modified Newton-Raphson method, convergence criteria, selection of appropriate analysis method, number of load steps, maximum number of iterations per step, convergence limits, load versus displacement control, arc-length methods, case studies in nonlinear finite element software, von Mises truss, elastic and elastic-plastic buckling of bars in compression, buckling of frames, cylindrical shells, unstiffened and stiffened plates, local buckling, design methodology of steel structures employing nonlinear finite element analyses.	4×3=12
6	Applications from research	Nonlinear in-plane behaviour of arches and corresponding design methodology, local buckling of wind turbine towers near the man-hole and evaluation of strengthening methods, interaction of global buckling, local buckling and material yielding in built-up columns, fatigue of wind turbine tower connections.	1×3=3
7	Applications from structural engineering practice	Design of beams with varying cross-section for the steel roof of Panathinaikos stadium in Votanikos, design of pylons and main girders with varying cross-section for the steel roof of Aristotle's Lyceum protection shelter, design of buried oil pipeline between Thessaloniki and Skpje at crossings of active seismic faults, design of façade and dome of Oval Tower in Limassol, Cyprus.	1×3=3
8	Presentation of term projects	Oral presentation of term projects.	1×3=3

Learning Objectives

In this course it is attempted to provide balance between acquiring knowledge of the theoretical background of nonlinear structural behaviour and expertise in applied analysis and design methods. Initially simple models are treated analytically, aiming at qualitative understanding of concepts and problems. This is followed by a numerical treatment with the finite element method to confront these issues in realistic complex structures. Upon the successful completion of the course, the students will be able to:

- understand the theoretical background of ULS checks of steel members according to Eurocode 3;

- identify cases in which nonlinear analyses are required for the design of a steel structure;
- design unconventional steel structure by means of nonlinear numerical analyses.

Mechanics of Masonry

Course Description

Mechanics of masonry at material level, description and interpretation of behaviour and design models for normal and accidental actions (earthquake). Introduction to the principles of assessment and rehabilitation of existing masonry structures.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Basic definitions. Physical and mechanical properties of materials (masonry units, mortar). Design values and partial safety factors	1×3=3
2	Masonry in compression	Behaviour model, effect of parameters on the compressive strength of masonry, uncertainties	1×3=3
3	Masonry in compression and flexure (buckling)	Behaviour model, design of masonry	1×3=3
4	Masonry under in-plane shear	Failure modes, behaviour models, design	1×3=3
5	Masonry under out-of-plane bending	Failure modes, behaviour models, design	1×3=3
6	Reinforced masonry	Technological aspects, steel-mortar bond, mortar-masonry unit bond, behaviour models, design	1×3=3
7	Masonry buildings under seismic actions	Behaviour, typical damage, Code provisions, behaviour models, design	3×3=9
8	Existing masonry buildings	Description of existing buildings, typical materials, typical damage	1×3=3
9	Documentation of existing buildings	Parameters to be assessed (and their effect on the behaviour of structures), in-situ and in-laboratory investigation techniques	2×3=6

#	Title	Description	Hours
10	Introduction to intervention techniques	Description and design of common intervention techniques (grouts, ties, enhancement of diaphragm action, etc.)	1×3=3

Learning Objectives

Upon successful completion of the course, students will have acquired knowledge on:

- basic properties of masonry materials (modern and existing);
- the theory of behaviour of masonry under normal and seismic actions;
- the significance of construction details, as well as the physical justification of design models;
- design of buildings made with plain and reinforced masonry;
- the basics of assessment of existing masonry buildings.

Ecological Models for Surface Water

Course Description

Introduction to ecological modelling and its practical significance in facing the main environmental problems in surface and coastal waters. Main types and characteristics of ecological models. Formulation, calibration, verification and application of a mathematical model. Modelling organic pollution and eutrophication in rivers. Modelling eutrophication in lakes/reservoirs and coastal waters. Hydraulic-habitat modelling in rivers. Team projects.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	The Water Framework Directive (WFD). Ecological problems and anthropogenic pressures. Biological characteristics of a water body. Basic physicochemical, biological and hydro-morphological quality elements. Principles for the classification of ecological and chemical status of surface water bodies. The main environmental problems in surface and coastal waters: organic pollution and de-oxygenation in rivers, eutrophication in lakes/reservoirs and coastal waters, and hydro-morphological alterations in rivers.	1×4=4
2	Main Types And Characteristics Of Ecological Models	Ecological models, their main types and their characteristics. Mathematical description of the most important physical, chemical, biological and ecological processes taking place in a surface water body. Formulation, calibration, verification and application of a	2×4=8

#	Title	Description	Hours
		mathematical model. Pressures and impact analysis. Methods for the assessment of point and non-point pressures.	
3	Modelling Organic Pollution And Eutrophication In Rivers	Scope of modelling and problem formulation. Classes of water quality in rivers. The processes of organic pollution in rivers and their equations. Team project 1: Formulation of a simple model for organic pollution and eutrophication in a river.	3×4=12
4	Modelling Eutrophication In Lakes/Reservoirs And Coastal Waters	Scope of modelling and problem formulation. Types of eutrophication models. Mathematical formulation – application of a eutrophication – dissolved oxygen model. Team project 2: Formulation of a simple model for eutrophication in lakes/reservoirs and coastal waters.	3×4=12
5	Hydraulic-Habitat Modelling In Rivers	Scope of modelling and problem formulation. Problem formulation. Description of the basic features of the hydraulic-habitat models. Team project 3: Formulation of a simple hydraulic-habitat model.	3×4=12
6	Presentation Of Case Studies.	Presentation of the team projects by the students and discussions.	1×4=4

Learning Objectives

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

- learn the basic types and characteristics of ecological models and the recent research findings in this field;
- combine teamwork with the theoretical knowledge;
- understand how ecological models can be employed as valuable tools to facilitate water resources management;
- develop and apply simple ecological models;
- evaluate through the use of ecological models the environmental impacts of the disposal of pollutants to the water environment;
- participate in integrated water resources projects and learn through conducting their ‘own research’ and deriving ‘their own findings’.

Integrated Project in Geotechnical Engineering

Course Description

As part of the course the students consider, as a starting point, the geotechnical aspects that affect the development of civil engineering projects. The variety of geological formations in the area of the project is initially recognized. The study of geotechnical investigations performed on the site of proposed structures/earthworks to obtain information on the physical properties of soil and rock around the site and to determine the parameters that govern their engineering behaviour when acting as foundation materials, follows. Laboratory and in situ testing measurements are taken into consideration to determine soil properties. Finally, the foundation design principles are applied using a design-oriented approach addressing soil models, numerical calculations, strategic analysis and design. Soil structures, such as retaining walls, slopes, embankments in the area of the project are also analysed and designed.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Introduction, presentation of available projects, group formation and project and supervisor assignment.	1×3=3
2	Project implementation	Description, geological maps, borehole data. Determination of soil parameters per soil layer, soil model, numerical calculations and dimensioning. Technical report and calculations appendix. Construction issues. Scheduling.	11×3=33
3	Presentation	Power point presentation	1×3=3

Learning Objectives

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

- understand how geotechnical engineering aspects affect the development of civil engineering projects and associated construction works;
- design foundations of structures and earthworks, retaining walls and slopes as required by the project;
- implement their theoretical knowledge to real problems.

Integrated Project in Structural Engineering

Course Description

Integrated structural design of a Civil Engineering structure by a group of 5 students. The subject will be selected by the students from a reservoir of subjects offered by the teachers. It will be supervised by an academic staff member through weekly meetings that substitute the courses. The students shall make a layout of the structure, built a numerical model in an appropriate software, run the analysis, design the structural elements, make structural drawings, submit a design report and make an oral presentation.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Presentation of the course procedure. Nomination of the groups, selection of a subject (from a reservoir) and a supervisor. If needed a 2nd supervisor will aid the group.	1×3=3
2	Project work	Project description- architectural drawings. Selection of structural system and form, structural modelling via CAD-BIM, Selection of materials, loads and load combinations, structural analysis, structural design, Design report, structural drawings in electronic form, structural details, erection, programming, cost statements	11×3=33
3	Presentation	PowerPoint presentation in public	1×3=3

Learning Objectives

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

- comprehend the complicated problems that arise in design of civil engineering works;
- design conceptually building and other types of structures;
- apply creatively the knowledge from previous courses in lower semesters;
- realize the structural design of a real structure up to a stage of final design.

Integrated Project in Transportation Engineering

Course Description

Integrated design of an integrated transportation project, preferably existing, by a group of 5 students. The topic is chosen according to the students' orientation and is supervised by a faculty member, through weekly meetings during the teaching hours. Within the framework of the integrated design, a project topic is formulated; in addition, design drawings, technical reports and calculation documents are produced.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Course presentation and structure. Creation of groups, topic selection (from exam paper repository) and supervisor faculty member choice (1 group/faculty member, if addition support is required from other faculty members, this will be up to the supervisor's initiative).	1×3=3
2	Assignments	Specification of the project to be studied. Definition of the work contents. Description of the methodology to be followed. Modelling- type analysis	11×3=33

#	Title	Description	Hours
		distinction: preliminary study-final. Dimensioning. Technical report. Calculations. Digital drawings. Construction issues. Programming. Cost analysis. Legal issues.	
3	Presentation	Project presentation in PowerPoint	1×3=3

Learning Objectives

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

- understand the complex problems that may be raised during the design of Transportation Engineering projects as well as grasp the systemic understanding and methodology in dealing with design processes;
- understand the reality and the consequences of the engineer's proposals in the design;
- apply creatively the knowledge gained from the courses of previous semesters;
- carry out the design of a real project at the level of final plan stage.

Integrated Project in Hydraulic Engineering

Course Description

To enable students to develop the skills required by civil engineering professionals in planning, designing, constructing and reporting integrated design of civil works related to water resources management. Projects will be conducted within a team that will consist of five students and will be supervised by a faculty member. The project subject will be selected by each team from a list of potential subjects that will be proposed by the faculty of the Department of Water Resources and Environmental Engineering. Project work will be coordinated and supervised through regular weekly meetings with faculty members that will review progress and guide the teams in the projects. Project work will include the design of all civil works either through computer simulations or desktop calculations, civil engineering drawings, all required calculations and technical report.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Scope of course, selection of student groups and project subject, appointment of at least one faculty member for each group.	1×3=3
2	Project work	Design of all civil works either through computer simulations or desktop calculations, civil engineering drawings, conduct all required calculations and technical report, prepare presentation.	11×3=33

#	Title	Description	Hours
3	Oral presentation	Oral presentation using PowerPoint	1×3=3

Learning Objectives

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

- learn about the design process through practice through implementation and understand the complexity of civil engineering works in the area of water resources management and environmental engineering;
- complete all process engineering calculations for the design of hydraulic works;
- complete all hydraulics calculations;
- choose site of facilities;
- carry out selection of major equipment;
- complete preliminary design of civil works related to water resources management and environmental engineering.

Experimental Hydraulics

Course Description

The course offers the basic knowledge necessary for experimental research and measurements in the fields of hydraulics and coastal engineering. It makes the student familiar with basic theory and applications as well as flow measurements in various experiments at the Applied Hydraulics Laboratory.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Dimensional analysis	Introduction, dimensional analysis, Buckingham π-theorem, applications.	1×4=4
2	Similarity theory and hydraulic models	Dimensionless Navier-Stokes equations, characteristic dimensionless parameters. Similarity theory. Full and partial similarity. Reynolds and Froude similarity. Theory regarding construction of hydraulic models. Visit at the Applied Hydraulics Laboratory, demonstration of experiments.	2×4=4
3	Measurement of flow parameters	Density, viscosity stage and pressure measurement in liquids. Static pressure measurement in the flow, Pitot tube. Flow rate measurement in pipes and open channels.	1×4=4

#	Title	Description	Hours
4	Error analysis	Experimental error estimates. Statistical analysis of experimental measurements.	1×4=4
5	Turbulence measurement-data acquisition	Turbulence and response of measurement instruments in time-dependent flows, spectra of turbulence, measurement of turbulent flow, Nyquist frequency.	1×4=4
6	Turbulence measurement devices	Laser-Doppler anemometry (LDA). Hot and cold wire anemometry (HWA). Laser-induced fluorescence (LIF), planar LIF (PLIF), particle image velocimetry (PIV).	1×4=4
7	Experiments-laboratory exercises	1. Flow meter calibration, friction and local energy losses in pipe flow. 2. Velocity and shear stress measurements in open channel 3. Velocity measurements in a turbulent air jet. 4.Turbulence temperature measurements in a heated jet. 5. Drag coefficient of a circular cylinder in water tunnel flow. 6.Presentation by the students and questions by the instructors regarding their experimental findings.	6×4=24

Learning Objectives

- Basic knowledge of dimensional analysis and similarity theory that is useful in experimental research and measurements in the laboratory in experiments regarding hydraulics as well as coastal hydrodynamics.
- Get familiar with laboratory measurements and data analysis.
- Be able to design experiments and hydraulic works related models.
- Ability to estimate experimental errors.

Environmental Impacts

Course Description

Presentation of the theoretical, historical and legislative framework for environmental impact assessment (EIA). Detailed description of procedures and preconditions for environmental licensing with emphasis on civil and environmental engineering applications. Evaluation of environmental impacts and life cycle analysis. Detailed presentation of the stages of environmental impact studies (EIS). Split class into 4-person study groups. Undertaking and elaboration of an actual EIS for a real-world project with a written deliverable (the actual EIS as submitted to the licensing authority) and a final oral EIS presentation and course exam.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Sustainable development and environmental policy. Environmental policy dimensions and evaluation of relations, positive and negative, between the proposed project or facility and the environment.	1×3=3
2	Environmental Licensing	Impact categories, impact assessment, decision making, response and monitoring measures, principles of environmental law, legal framework, environmental impact assessment, assessment methodology, Environmental Impact Studies (EIS) content, environmental permitting process, EIS assessment criteria, environmental approval and licensing.	1×3=3
3	Calculation of Impact-Life Cycle Assessment (LCA)	Empirical Methods, Leopold Tables, Measurement of Specific Parameters and Indicators, Overlapping Method, Impact List Method, Network Method, Battelle Index System. LCA purpose, life cycle stages, LCA methodologies, applications	1×3=3
4	Presentation Of Waste Management Case Study	Legislation - institutional guidelines for solid waste management, basic principles of cyclical economy, waste production and stages of urban waste management, management hierarchy, environmental impacts, alternative technological approaches, siting. EIS case study for a landfill, location and history, waste management plan, operation description & waste data, output data (biogas - leachate), field measurements.	2×3=6
5	Elaboration of EIA for real technical work	Upon completion of the theoretical lectures, class is split into 4-person study groups, where each group undertakes a real-world project, aiming at the preparation of an Environmental Impact Study (EIS) under the close supervision of a professor with technical expertise in the specific project area. Projects are mostly large infrastructure projects (waste management, transportation, water resources, energy, marine and coastal, etc.). The implementation of the project is based on the material collected and/or provided to the members of the OM, the course specific guidelines (posted on the website) and the supervisor's guidelines. Groups meet regularly with the supervisor to present their progress and discuss/resolve any arising issues all the way to project completion. Project completion entails the preparation of the final course deliverable, the actual EIS as submitted to the licensing authority.	8×3=21

Learning Objectives

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

- have an adequate knowledge and understanding of the theoretical, historical and legal environmental impact frameworks;

- have an adequate knowledge and understanding of the necessity, different processes and preconditions of environmental licensing for civil and environmental engineering works;
- apply different environmental impact assessment and pertinent life cycle analysis methodologies;
- appreciate and comprehend the importance of circular economy and sustainability considerations in civil works;
- conduct, effectively present and be able to defend as a team a real-case environmental impact assessment study for selected civil works projects.

Environmental Geotechnics

Course Description

The object of Environmental Geotechnics is the protection of the subsurface (soil and groundwater) from potential pollutants related primarily to waste management (e.g. landfills) and to transporting, storing and handling toxic raw materials (e.g. petroleum products, solvents). The course aims to promote (a) comprehension of the main processes that govern the spreading of pollution and its containment, (b) judicious application of the equations describing these processes and (c) familiarization with case studies of contaminated sites.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Introduction with one case study from Greece and the essential questions answered by the course: (1) What is the danger (from pollutants)? (2) Where will the pollutant go, how will it behave? (3) What can we do to reduce the danger? (4) When do things are relatively easy or difficult and why? Overview of legislation, contaminant sources and characteristics.	3×2=6
2	Risk Assessment	This unit addresses essential question No 1 and rephrases it introducing the concept of risk, so that the answer can be used in decision making regarding possible remediation needs at contaminated sites.	2×2=4
3	Mechanisms of pollution spreading	Qualitative study of pollution spreading (start with a qualitative answer to essential question No 2 and continue with quantitative answers in Units 4, 5, 6, 7).	2×2=4
4	Subsurface flow	One-dimensional steady-state flow in saturated soil, equations for multi-phase fluid flow in porous media.	3×2=6
5	Modelling of physical systems	Guidelines for converting an open-ended problem to a fully-defined problem ready for solution.	1×2=2

#	Title	Description	Hours
6	Soil-contaminant interaction	Distribution of contaminants among the subsurface media, i.e., groundwater, soil pore gas, soil solids. Calculation of total contaminant mass in the subsurface.	3×2=6
7	Contaminant transport in groundwater	Quantitative study of pollution spreading: bringing together the phenomena of advection, diffusion, mechanical dispersion, sorption and pollutant decay in the mathematical description of contaminant transport in 1, 2 and 3 dimensions.	6×2=12
8	Remediation technologies for contaminated sites	Overview of remediation technologies and application of contaminant transport principles to the solution of remediation problems (essential question No 3).	3×2=6
9	Landfill liner design and materials	Design of landfill liners, materials used in compacted and geosynthetic clay liners (essential question No 3).	1×2=2
10	Wrapping up	Answers to the essential questions (see Unit 1) – essential question No 4 requires a synthesis of Units 4, 6-8.	1×2=2

Learning Objectives

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

- locate reliable data on the effects of contaminants on human health;
- confidently apply principles of mass transfer, groundwater flow and contaminant transport to problems of contamination and restoration of the subsurface;
- address the geoenvironmental aspects of landfill and clay barrier design;
- recommend potentially suitable remediation technologies for a specific contaminated site;
- take initiatives related to modelling (i.e. related to the formulation of a simplified problem that admits solution).

Environmental Hydraulics

Course Description

Introduction: concepts and definitions, pollution and transport processes of pollutants in water and air ambients. The one-dimensional equation of molecular diffusion: derivation and analytical solutions. The one-dimensional equation of advection-diffusion: derivation and analytical solutions. Mixing in rivers: turbulent diffusion and dispersion. Physical, chemical and biological processes. Numerical models for simulating the water quality: numerical solution of the one-dimensional dispersion equation, application in the pollutant dispersion in a river. Turbulent buoyant flows: jets, plumes, buoyant jets. Diffusers, application to the disposal of effluents. Design of effluent discharge systems.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Introduction: Basic definitions. Practical problems in Environmental Fluid Mechanics. Pollution and transport processes of pollutants in water and air ambients. Near and far field. The effect of flow field on the pollution, the fundamental flow equations describing the hydrodynamic behaviour (equations of flow field) and the pollution (equations of quality characteristics), and the respective mathematical models.	1×3=3
2	One dimensional equation of advection-diffusion and analytical solutions	Molecular diffusion. The one-dimensional equation of molecular diffusion: derivation based on Fick's law and analytical solutions. The one-dimensional equation of advection-diffusion: derivation and analytical solutions.	2×3=6
3	Mixing in rivers: Turbulent diffusion and dispersion	Mixing in rivers: turbulent diffusion and dispersion. The equation of advection-diffusion for turbulent flow. Longitudinal dispersion. The one-dimensional equation of dispersion. Analytical solutions and applications.	1×3=3
4	Physical, chemical and biological processes	Chemical, physical and biological processes (basic definitions, reaction kinetics) and processes at interfaces: processes at the interface of air-water (aeration models) and at the interface of water-suspended solids (models of suspended solids). Introduction of processes in the one-dimensional equation of dispersion.	1×3=3
5	Numerical models for simulating the water quality	Numerical simulation using finite differences. One-dimensional models of water quality and applications. Pollution (deoxygenation) of river. Numerical solution of the one-dimensional dispersion equation. Application in the dispersion of pollutant in river.	2×3=6
6	Turbulent buoyant flows	Disposal of effluents in coastal waters and buoyant flows, near and far field. Basic definitions and flow parameters. Turbulent jets, plumes, buoyant jets. Investigation with dimensional analysis. Calculation of basic flow parameters for different ambient conditions (effect of stratification and cross flow). Diffusers. Application to the disposal of effluents. Disposal of thermal waters and brine from desalination plants.	3×3=9
7	Design of effluent discharge systems	Submarine outfall pipes. Application to the disposal of effluents using a software. Hydraulic design of a diffuser.	3×3=9

Learning Objectives

- Understanding the transport processes of pollutants in water and air ambients and of their mathematical description.
- Solution of the one-dimensional equation of advection-diffusion for calculating the concentration of a pollutant which is dispersed in a river taking into consideration physical, chemical and biological processes.
- Approach of turbulent buoyant jets using dimensional analysis.
- Calculation of the dilution of effluents for different ambient conditions and acquisition of the necessary knowledge for the design of effluent discharge systems.

Quantitative Methods in Transportation

Course Description

The aim of the course is to introduce students to advanced concepts of quantitative methods in the analysis of transport systems operation. Teaching includes topics such as, intelligent transport systems, network optimization, optimization methods, real-time management systems, telematics systems, centralized and distributed control, decision-making methods, applied statistical modelling, regression, methods of stated and revealed preference, analysis of time series, forecasting methods, machine learning techniques. All of the course's applications are developed in the R open source software. The weekly program includes 4 teaching hours of theory and applications. During lecture time applications and exercises are solved and no clear distinction between theory and exercises exists. The course includes 4 mandatory exercises and 1 oral examination.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Intelligent Transport Systems	Introduction. Systems. Processes and Patterns. Databases. Introduction to Quantitative Methods.	2×4=8
2	Applied Statistical Modelling	Databases Analysis and Hypothesis Testing. Linear and Logistic regression, methods of stated and revealed preference. Time series Analysis.	4×4=16
3	Optimization	Transport and allocation problems. Optimal design problems. Advanced traffic assignment methods and Public Transport. Intelligent Transport Systems and Optimization.	3×4=12
4	Programming in R	Introduction to R. Basic Programming Concepts. Classification, clustering, optimization and forecasting techniques in transportation using R.	4×4=16

Learning Objectives

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

- know the basic categories of quantitative methods they can apply to transport problems;
- understand the influence of quantitative methods on modern intelligent transport systems;
- understand the importance of open source software and programming in dealing with transport problems;
- develop programming code for the implementation of models in order to solve transport problems;
- evaluate these models in terms of their usefulness and credibility.

Internship

Course Description

The specific course concerns the Internship of students at a full time basis (8-hour working days of the week) in private companies or public organizations (e.g. Athens Water Supply and Sewerage Company, Earthquake Planning and Protection Organization, Greek Railways Organization etc.) on subjects relevant to Civil Engineering background. The course is mandatory by election in the 9th Semester for all concentrations and is carried out in the 10th Semester. In exceptional cases students of other semesters may participate in this course. The Internship is performed for a period of 2 consecutive months (e.g. from March to July or during September-October). The Internship is co-funded by the European Union (European Social Fund (ESF) and National Resources (through funds managed by the NTUA).

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Summary	Internship entails the training of students at an Organization/Company according to the working hours of the Organization/Company (regularly morning hours, for 8-hour working days of the week) and lasts for 2 consecutive months. The student is entitled to leave for 2 days in total. His total employment is in the order of 330 hours.	

Learning Objectives

Internship contributes to a more meaningful connection of NTUA with the production environment and essentially supports:

- the consolidation of the theoretical and technological background of the students through their implementation in practice as well;
- the familiarization of students with the real working environment and conditions.

Prestressed Concrete

Course Description

Introduction. Basic concepts. Materials, prestressing systems and anchorages. Partial losses due to friction, anchorage slip, creep, shrinkage and relaxation, Serviceability limit state design: flexural and shear design. Final design of prestressed concrete structures. Ultimate limit state design. Prestressed concrete technology and detailing. Design of anchorage systems. Statically indeterminate prestressed concrete structures.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Fundamental concepts and principles Prestressed vs reinforced concrete Methods of application of prestress Types and classes of prestress	1×4=4
2	Preliminary verifications and dimensioning at serviceability	Preliminary dimensioning of sections. Allowable stresses Assessment of required prestressing force	3×4=12
3	Immediate prestress losses	Losses due to friction - anchorage slip. Elastic shortening The concept of equivalent loads	1×4=4
4	Time dependent prestress losses	Creep and shrinkage phenomena explained. Relaxation of steel. Calculation of corresponding losses	1×4=4
5	Flexural stress verification at serviceability	Changes of sectional properties Calculation of flexural stresses at different loading stages	1×4=4
6	Ultimate limit state in bending with or without axial force	Steel elongation at decompression. Design loads. Fundamental design assumptions. Design methods and aids. The case of compression flanges. Brittle failure avoidance	2×4=8
7	Ultimate limit state in shear	Design loads - Shear due to prestress Design of sections without flexural cracks Design of cracked sections	1×4=4
8	Indeterminate structures	Analysis methods Use of equivalent loads Guidance for selecting tendon profiles	1×4=4
9	Anchor zones of post tensioned tendons	Design methods Local zone - Splitting forces General zone - Bursting forces Design arrangement of end block reinforcement	1×4=4
10	Anchor zones of pretensioned tendons	Definition of Transmission - Dispersion and Anchorage length	1×4=4

Learning Objectives

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

- know the basic material properties and technical characteristics of pre- and post-tensioning;
- know the prestressing technics;
- know the basic theory of prestressed concrete and the required verifications;
- design a prestressed structure (dimensioning, detailing, designing drawings) under the design actions.

Stochastic Methods

Course Description

Simulation and its importance. Review of probability theory and statistics. Stochastic processes and time series. Spectral analysis. Stochastic differential equations. Stationary univariate stochastic models. Long term persistence and simple scaling processes. Cyclostationary models. Multi-variate stochastic models. Discretization methods. Series expansion methods. Stochastic analysis of simple structural systems.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	General notions, uncertainty and its quantification, usefulness and problem types.	1×3=3
2	Simulation	The notion of simulation, categories of simulation, use of stochastic simulation, simulation models, random numbers. Simple examples of simulation in problems of statistical induction, Monte Carlo integration and stochastic optimization.	1×3=3
3	Review of probability theory and statistics	Random variables, statistical parameters, statistical estimation, probability distributions and their fitting. The notion of entropy and its maximization. Application to statistical analysis of geophysical time series.	1×3=3
4	Stochastic processes and time series	Stochastic processes, stationarity, ergodicity. Autocorrelation, cross-correlation, climacogram. Stochastic processes in discrete and continuous time. Sampling and times series. White noise.	1×3=3
5	Spectral analysis	Fourier transform and its usefulness for solving integral equations. Convolution. Fourier transform of the autocovariance function and power spectrum. Power spectral estimation from time series. Computational aspects of power spectrum. Example on	1×3=3

#	Title	Description	Hours
		identification of periodicity. More complex example of analysis of large scale geophysical time series.	
6	Stochastic differential equations	General notions, the Langevin equation and its application to the problem of outflow from linear reservoir with white noise inflow. Fokker–Planck equation. Markov processes, the Ornstein–Uhlenbeck process.	1×3=3
7	Univariate and stationary stochastic models	Discrete time models. Models AR(1), AR(2), ARMA(1,1), and their generalizations. The general simulation method of any arbitrary process using the SMA method. Fitting of stochastic models based on time series data and generation of synthetic time series.	1×3=3
8	Long term persistence and simple scaling processes	Empirical validation of the existence of long-term persistence. Theoretical derivation based on the maximization of entropy production. The Hurst-Kolmogorov process and simple methods of simulating it. Analysis of the effect of long-term persistence on the availability of water resources and on the design of water development projects.	1×3=3
9	Cyclostationary models	Introduction to cyclostationarly models. The PAR and PARSMA models. Application to reservoir design of and stochastic reliability analysis.	1×3=3
10	Multivariate models	Review of linear algebra topics. Vector random variables and their manipulation. Covariance matrices. The multivariate cyclostationary model PAR. Introduction to disaggregation models. Application to reservoir systems management.	1×3=3
11	Series expansion simulation methods	Simulation of stochastic processes with point discretization methods and local averages. Spectral representation and Karhunen–Loève series expansion methods. Simulation of stationary stochastic processes.	1×3=3
12	Simulation of nonstationary processes	Simulation of nonstationary stochastic processes and power spectra estimation from real data. Production of synthetic seismic ground motions - accelerograms.	1×3=3
13	Stochastic analysis of simple structures	Introduction to stochastic virtual work principle. Solution of the stochastic static problem using analytic solutions as well as Monte Carlo simulation approximations. Estimation of response variability.	1×3=3

Learning Objectives

- Familiarization with uncertainty, inherent in complex but also in simple systems.
- Understanding the potential of Monte Carlo simulation for stochastic numerical problems as well as in deterministic ones.

- Familiarization with stochastic calculus.
- Learning how to use simple stationary and cyclostationary stochastic models for simulation purposes.
- Understanding the notion of persistence and its effect on the uncertainty increase and the design of engineering projects.
- Familiarization with stochastic process simulation methods and their relation to the corresponding physical processes.
- Understanding the formulation and solution of structural mechanics problems in the presence of uncertain parameters.
- Understanding the effect of uncertainties in the analysis and design of structures.

Combined Transport - Advanced Systems

Course Description

Combination of transport modes. Systematic analysis of modes, evolutionary trends, terminals and operational cost for different transport modes (road/rail/air modes, public transport, combined transport and unitized cargoes. Operation and Exploitation. Just-in-time methods. Demand Management. Organization of transport systems and terminal design. Operating cost of transportation projects. Energy and environmental aspects of transportation.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Basic Definitions. Unitized cargo. Systematic analysis of modes, evolutionary trends, operational cost (Theory).	2×4=4
2	Terminal Design	Transport Systems organization. Terminal design for cargo handling with emphasis on container terminals. Problem solving by use of Queuing Theory and Simulation models (Theory and Exercises)	10×4=40
3	Cost and Demand	Demand management. Operating cost of transport projects (Theory and Exercises).	1×4=4
4	Energy and Environment	Energy and environmental aspects of transportation (Theory)	1×4=4

Learning Objectives

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

- identify the basic types of unitized cargoes, the handling equipment at the yardside and landside of the terminals as well as the alternative organizational schemes of the associated operations.

Moreover, the students will have a full understanding of the 3 methods used to design port terminal layouts (numerical method, queuing theory and simulation);

- realise the interrelationship among individual choices and how they should be made in order to produce the best result;
- understand (a) the impact of the above choices in terms of space and cost requirements for the installations and (b) that identifying the adequate method to determine the terminal layout is strongly depended on the type of problem under investigation;
- construct calculation models for terminal design following the 3 methods (numerical method, queuing theory and simulation);
- calculate the area demand, the number of equipment and in general be able to estimate the basic dimensions and requirements of cargoes han.

Composite Materials

Course Description

Technical background and development of composite materials. Production procedures. Mechanical behaviour of composite materials. Hooke's law for orthotropic and anisotropic materials. Rule of mixtures. Micromechanical and macromechanical properties. Membrane, bending and combined loading of laminates. Failure criteria for plies and laminates. Experimental procedures for determining the properties of constituent materials, plies and laminates. Fracture mechanics of composite materials. Viscoelastic behaviour. Analysis of damping. Aging and fatigue. Interlaminar stresses and delamination criteria. Hygrothermal behaviour. Analysis of structures made from composites. Applications using the finite element method.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction	Technical background and development of composite materials. Production procedures.	1×3=3
2	Mechanical behaviour of FRP.	Hooke's law for orthotropic and anisotropic materials. Rule of mixtures.	1×3=3
3	Mechanical properties	Micromechanical and macromechanical properties. Properties of plies, and laminates	1×3=3
4	Axial and bending behaviour	Membrane, bending and combined loading of laminates	1×3=3

#	Title	Description	Hours
5	Failure criteria	Failure criteria for plies and laminates. Maximum stress and maximum strain criteria, Tsai-Hill and Tsai-Wu criteria.	1×3=3
6	Experimental procedures for FRP	Experimental procedures for determining the properties of constituent materials, plies and laminates.	1×3=3
7	Fracture of FRP	Fracture mechanics of composite materials. Criteria Whitney-Nuismer	1×3=3
8	Viscoelastic behaviour	Viscoelastic behaviour. Analysis of damping.	1×3=3
9	Aging and fatigue	Aging and fatigue of FRP. The time-temperature scale	1×3=3
10	Interlaminar stresses	Interlaminar stresses and delamination criteria	1×3=3
11	Hygrothermal behaviour	Hygrothermal behaviour.	1×3=3
12	FE Applications on FRP	Examples with 2D Laminate plate elements (Layered elements)	2×3=6

Learning Objectives

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

- determine the basic characteristics of the mechanical behaviour of FRP materials and the stress state of FRP plies and laminates;
- deal with ply failure, delamination failure, ageing, fracture fatigue and hygrothermal effects of FRP materials;
- gain the basic knowledge for design of structures made from FRP composites.

Boundary Elements

Course Description

Learning the method of boundary elements to solve engineer problems.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	Introduction	Introduction. Boundary Elements and Finite Elements. Historical development of the BEM.	1×4=4
2	The direct BEM for the Laplace and the Poisson equation	Preliminary Mathematical Concepts. The BEM for potential problems in two dimensions.	3×4=12

#	Title	Description	Hours
3	Numerical Implementation of the BEM	The BEM with constant boundary elements. Programming the method using Fortran or/and Matlab.	2×4=8
4	Dual Reciprocity	The Dual Reciprocity Method. Domains with multiple boundaries. The method of subdomains.	2×4=8
5	Applications	Torsion of non-circular bars. Deflection of elastic membranes and simply supported plates. Heat transfer problems and Fluid flow problems.	3×4=12
6	The BEM for nonhomogeneous bodies	Solutions of problems with unknown fundamental solutions. Applications. Potential problems to bodies with variable properties.	2×4=8

Learning Objectives

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

- understand the Boundary Element Method and its PC programming;
- calculate real implementation cases using the relevant software codes.

Airport Planning and Management

Course Description

Introduction to Airport Planning Design and Management. Helps students to understand and develop the principles of the systemic approach in the analysis, planning and design of large scale complex infrastructures such as airports. Planning of airport systems requires a wider view and understanding that departs from the strictly technical engineering context and addresses economic, business and legal issues. Dynamic Strategic Planning is discussed. Planning, design and management of airside and landside are also presented.

Semester: 9

Teaching hours: 4

Course Units

#	Title	Description	Hours
1	The New Environment	The new environment in air transport (privatization and deregulation, commercialization, hub airports, multi-airport systems) and their impact to airport planning.	2×4=8
2	The Airport	Airport operations, subsystems, international differences in the design, the Greek airports, runway orientation and wind rose.	1×4=4

#	Title	Description	Hours
3	Dynamic Strategic Planning	Feasibility, Dynamic Strategic Planning, forecasting models, uncertainties and risks, decision and option analysis, design hour, site selection, MASTER PLAN, airport layouts and financing.	2×4=8
4	Airside	Airport classification and design standards, airport layouts and geometry, obstacle limitation surfaces	2×4=8
5	Landside	Configuration of passenger buildings, overall design, detailed design of passenger buildings, capacity, operation, management, ground access and distribution, parking and people movers	2×4=8
6	Site Visit	Visit to "El. Venizelos" Athens airport.	1×4=4
7	Capacity-Demand Management	Airfield capacity, airfield delay, demand management, air traffic management	2×4=8
8	Environmental Impacts-User Charges	Environmental impact (noise, air quality, water quality control, wildlife), types of airport user charges, heliports, general aviation	1×4=4

Learning Objectives

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

- familiarise themselves with the airport system and subsystems;
- understand the reality (new era) and the consequences of airport planning process, through different examples;
- familiarise themselves with the planning, operation and management of airports;
- familiarise themselves with the standards in airport design;
- understand the principles and methodology of the systemic approach in the analysis, planning and design of large scale and complexity infrastructures.

Technology of Building Information Modelling (BIM)

Course Description

H The BIM technology as applied for the design, the management and the operation of construction works. From 2D design of a construction project to the 3D project information model compiled with intelligent objects. Basic BIM terms and definitions. Open standards for interoperability and organizational requirements. Integration of the architectural, the structural and the E&M BIM Models and model integrity checking. Model uses for project planning and scheduling, cost estimation and construction visualization. BIM for Facility Management.

Semester: 9

Teaching hours: 3

Course Units

#	Title	Description	Hours
1	Introduction to BIM Technology	From 2D design of a construction project to the 3D project information model. The intelligent BIM Objects and the data content of a BIM model. Application fields and uses of BIM technology. Instructions for the course organization and free software tools for the curse (Revit & Navisworks, Synchro, BIM viewers etc). Sources for information and tools in the Web.	3×1=3
2	BIM Terms and Definitions – BIM Standards	Basic terms and definitions relevant to BIM technology. BIM maturity levels. Open standards for interoperability (IFC, COBie, etc). Organizational requirements. Web based collaboration platforms.	3×1=3
3	Building Design with BIM 1	Setting up the architectural model. Model insights. Authoring tools. The intelligent objects. Level of Detail	3×1=3
4	Building Design with BIM 2	Setting up the structural model. Model insights. Authoring tools. The intelligent objects. Level of Detail. Merging with the architectural model. Clash detection.	3×1=3
5	Building Design with BIM 3	Setting up the structural model. Model insights. Authoring tools. The intelligent objects. Level of Detail. Merging with the architectural and the structural models. Clash detection.	3×1=3
6	Design of Infrastructures with BIM	BIMΓ for Infrastructure, Civil Information Modelling. BIM uses for the design of road projects and bridges. Authoring tools.	3×1=3
7	BIM for Project Management 1	BIM uses for quantity take off. Setting up the 4D BIM model for time scheduling and project monitoring. Authoring tools. Cloud PM platforms.	3×1=3
8	BIM for Project Management 2	Use of the 4D BIM model for the visualization and simulation of the construction process, planning optimization, site organization, safety management and constructability review.	3×1=3
9	BIM for Project Management 3	Setting up the 5D BIM model for cost estimating and project budgeting	3×1=3
10	BIM for Project Management 4	Presentation of subjects to be assigned as Homework. Assignments reinforce all of the material covered, and are required to be submitted by the due date indicated on the Schedule of Sessions.	3×1=3
11	Field BIM	Use of the BIM model on Site for project monitoring and control. Link with VR and AR applications.	3×1=3

#	Title	Description	Hours
12	BIM for Facility Management	Setting up the 6D BIM model for the Facility Management and the Operation Management of the built assets. Setting up a 3D BIM mode of an existing asset with 3D laser scanning (LiDAR, etc)	3×1=3
13	Project presentation	Submittal and presentation of the assigned projects	3×1=3

Learning Objectives

Upon successful completion of the course, students will be able to demonstrate knowledge and understanding of:

- the concepts and processes of Building Information Modelling and of a wide range of BIM applications used in the architecture, engineering and construction (AEC) industry;
- the Building Information Modelling and model-based engineering workflows in the building and infrastructure lifecycle;
- the Construction scheduling and 4D simulation technique as well as the model-based quantity take-off and cost estimation. The construction progress monitoring using a 4D BIM model with cloud and mobile applications;
- the Facility information modelling to support operation and maintenance of built assets;
- the benefits of using BIM to support project delivery collaboration and team-based workflows in the building and infrastructure lifecycle.