



## Study Plan

**School:** School of Sciences and Technology

**Degree:** Master

**Course:** Geological Engineering (cód. 654)

### 1st Year - 1st Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
MAT12516	Mathematical Analysis III	Mathematics	6	Semester	156
GEO7151	Geological and Mining Exploration	Geological Engineering	6	Semester	156
ERU7145	Soil Mechanics and Foundations II	Civil Engineering	6	Semester	156
GEO7168	Energetic Resources	Geological Engineering	6	Semester	156

#### Options

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO12519	Geotechnics in Communication Networks	Geological Engineering	6	Semester	156
GEO12520	Applied Geostatistics	Geological Engineering	6	Semester	156
FIS7164	Applied Geophysics	Physics	6	Semester	156

### 1st Year - 2nd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO7155	Thematic Mapping	Geosciences	9	Semester	234
GEO12517	Slope Stability	Geological Engineering and Environmental Sciences and Ecology	6	Semester	156
GEO7157	Quarry Technology	Geological Engineering	6	Semester	156
GEO12518	Seminar in Geological Engineering	Geological Engineering	3	Semester	78

#### Options

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
ECN7158	Natural Resource Economics	Economy	6	Semester	156
GEO10093	Applied Geochemistry	Geosciences	6	Semester	156
ERU12521	Building Materials	Civil Engineering	6	Semester	156

### 2nd Year - 3rd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO7169	Mining Technology	Geological Engineering	6	Semester	156
GEO7154	Environmental Rehabilitation	Geological Engineering and Environmental Sciences and Ecology	6	Semester	156



## 2nd Year - 3rd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
<b>Options</b>					
Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO12522	Petrogenetic Processes	Geosciences	6	Semester	156
GEO12523	Prospecting and abstraction of groundwater	Geosciences	6	Semester	156
GEO12524	Geotechnical works	Geological Engineering	6	Semester	156
Dissertation					
Report					
Project Work					

## 2nd Year - 4th Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					
Report					
Project Work					

## Conditions for obtaining the Degree:

\*\*\* TRANSLATE ME: Para aprovação na componente curricular é necessário a aprovação (através de avaliação ou creditação) das seguintes unidades curriculares:

1º Ano { \ }newline

{ \ }newline

1º Semestre:

4 UC obrigatórias num total de 24 Ects

1UC optativa num total de 6 Ects { \ }newline

{ \ }newline

2º Semestre:

4 UC obrigatórias num total de 24 Ects

1UC optativa num total de 6 Ects

2º Ano { \ }newline

{ \ }newline

3º Semestre:

4 UC obrigatórias num total de 12 Ects

1UC optativa num total de 6 Ects

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Para a obtenção do grau é necessária a aprovação na Dissertação ou Estágio ou Trabalho de Projecto, no 4º semestre com o total de 42 ECTS \*\*\*

## Program Contents



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### **Mathematical Analysis III (MAT12516)**

Elements of Differential Geometry in  $\mathbb{R}^3$ : Contours. Parameterization by arc length. Curvature and torsion. Frenet-Serret formulas. Tangent plane and normal line to a surface. Orientability.

Introduction to Complex Analysis: Complex functions and analytic functions. Cauchy-Riemann equations. Laplace equation. Harmonic functions. Geometry of analytic functions. Complex integration. Fundamental Theorem of Calculus. Cauchy's theorem and its evolution. Cauchy integral formula.

Ordinary Differential Equations: Exact equations and integrating factors. Equations of 1st order. 2nd order linear equations.

Systems of ordinary Dif. Eq.: Linear systems and with constant coefficients. Stability of solutions.

Fourier series. Periodic functions. Trigonometric series. Euler formulas for Fourier coefficients.

Convergence and the sum of the Fourier series. Functions with a generic period  $2L$ . Expansion in series of sines and cosines. Periodic extensions. Complex Fourier series. Fourier integrals.

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### **Geological and Mining Exploration (GEO7151)**

1. Mineral and mining economy.
2. Legislation of exploration and mining.
3. Resources and reserve concepts.
4. General notes on survey campaign preparation.
5. Introduction to prospecting methods.
6. Geological survey.
7. Geophysical survey
8. Geochemical survey.
9. Drilling and evaluation
10. Case studies of mineral resources prospecting/exploration in Portugal.

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### **Soil Mechanics and Foundations II (ERU7145)**

Introduction to the Eurocode 7. Characteristics of geotechnical design. Ultimate limit states and serviceability limit state. Safety check.

Geotechnical characterization. In-situ tests.

Shallow foundations. Bearing resistance; influence of geometry and loading on its value. Immediate and deferred settlements. Safety check.

Deep foundations. Types of piles, construction aspects and their influence on behaviour. Design against vertical loads. Load tests and their importance on the safety check. Settlements evaluation.

Earth pressures. Coefficient of thrust. Rankine theory. Coulomb method. Safety check of retaining structures to the ultimate limit states of overturning, sliding resistance, and bearing resistance of the foundation.

Slope stability. Types of sliding. Stability analysis: infinite slopes and slopes of homogeneous material. Methods of slices of Fellenius and Bishop. Stabilization methods.



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### **Energetic Resources (GEO7168)**

(Energy resources and society.

Energy resources and economy.

Coal: Genesis, typologies and exploitation.

Hydrocarbons (oil and gas): Genesis, migration and accumulation.

Unconventional hydrocarbons.

Methane hydrates.

Nuclear resources: Genesis and exploitation.

Geothermal resources: Genesis and exploitation.

The future of energy.

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### **Geotechnics in Communication Networks (GEO12519)**

Framework of the role of geotechnics in such ventures, given the various stages between the early studies and their exploitation.

Introduction to the figure of the Specifications as a document regulating the development of design and construction of the project.

Geotechnical requirements for determining and implementing the various phases of development of such projects:

- Phase of initial recognition;
- Phase of the project;
- Construction phase;
- Exploration Phase

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### **Applied Geostatistics (GEO12520)**

Introduction to different types of Geosciences data and to its collection and preparation.

Introduction to Geostatistics. R language as a tool for application in Geostatistics. Exploratory data

analysis. Spatial data prediction. Theory of regionalized variables. Analysis of the spatial data structure:

experimental variogram and modeling of the variogram. Geostatistical estimation or prediction: kriging.

Basics of multivariate data analysis. Main types of kriging: general characterization and exercises in R.

Geostatistical Simulation: general characterization and exercises in R.

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### **Applied Geophysics (FIS7164)**

I – Introduction - Forward and inverse problems in Geophysics. Physical properties. The signal in A. G.

II – Electrical methods – Electrical properties of rocks. Archie's Law. Concept of geoelectrical section. Wenner, Schlumberger, and dipole-dipole configurations. Electrical resistivity profiles and electrical soundings and their interpretation.

III – Gravimetric methods - Universal attraction. Geological and non-geological causes of gravity acceleration changes. Gravity meters. Gravity maps and profiles and their interpretation. Gravity response of some simple shapes.

IV- Seismic methods –Elements of Elasticity theory. Elastic constants and their physical meaning. Waves, wave reflection and wave refraction; Snell's Law. P and S waves. Reflection and refraction methods. Seismometers and geophones. Seismic refraction method; time-distance graphs and their interpretation.

V – Well logging – Electrical logs and nuclear logs.



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### **Thematic Mapping (GEO7155)**

Introduction: Cartography as science applied to geosciences.

Structural Mapping: Identifying, mapping and characterizing large-scale geological structures.

Structural contours maps and 3D dimensional models of structures. Mapping using GPS and GIS.

Mapping of mineral resources: Fundamentals of mineral cartography; mining maps (metallogenic provinces and mineral occurrences); classification of occurrences and their representation in a mining district; detailed mineral mapping; infrastructure maps; mining works surveys (trenches, galleries);

Geotechnical Mapping: The Geotechnical Mapping in Urban and Regional Planning. Typology of geotechnical maps and Geotechnical Units. Remote Sensing, field survey and use of GIS applied to Geotechnical Mapping. Geotechnical Units and Zoning Maps. Classification of terrains.

Application examples: Natural Resources; Suitability for Construction; Hazards; Environmental Protection; Exploitation of Construction Materials; Regional and Urban Planning.

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### **Slope Stability (GEO12517)**

Geotechnical Engineering:

Introduction: Fundamentals about the methodology of study and data processing concerning to slope stability problems; Methods of analysis on stability of slopes.

Selection of the stabilization design on soil slopes and rock slopes.

Stabilization of soil slopes: Modification of slope geometry; Drainage and surface protection; Mass reinforcement.

Stabilization of rock slopes: Fragmentation and removal of blocks; Slope geometry modification; Mass reinforcement; Measures to reduce the risk of rockfall.

Instrumentation and monitoring of slopes: Parameters to be measured; Type of instrumentation.

Soil Bioengineering:

Introduction to Soil Bioengineering.

Construction methods; Preparatory work: Sowings; Plantations; Techniques with herbaceous.

Techniques with woody plants; Techniques with vegetal associations; Combined methods of construction; Maintenance work.

Constructive design.

Shipyard management.

Maintenance.

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### **Quarry Technology (GEO7157)**

Theoretical

I - Legal framework of the national mining sector.

II - Economic background of the natural stone sector.

III - Development stages of a dimension stone quarry.

IV - Cycle characterization quarry works in extractive units carbonated ornamental stone, slates, granite and similar rocks.

V ? Open pit aggregate exploitation. Technical parameters for design of a mining unit.

VI - Cycle quarry works characterization in extractives units for the production of aggregates.

VII - Introduction for executing a quarry plan. Mining plan, PARP and Health and Safety Plan.

Practice

Exercises about management, planning and various technical aspects.

Technical visits to extractive units producing dimension stone and aggregates production.

Internship in quarry (where available).

MaxamPor training (15 hours) on industrial explosives and practice in quarry.



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### **Seminar in Geological Engineering (GEO12518)**

1. Formal standards of research.
2. Theory of scientific production. Determination of the scientific domain. The importance of interdisciplinarity.
3. Stages of research: office data collection, field studies (surface exploration, subsurface exploration, "in situ" testing), laboratory testing, processing of data obtained, discussion and interpretation of results, conclusions and future perspectives.
4. Methods. The comparison of the sources. Summary, citation and reference. The determination of the problem and research hypotheses. The preparation and presentation of the thesis.
5. International standards for the preparation of articles and papers in engineering.
6. The phases of the project. Feasibility study, preliminary project, final project, construction, post project monitoring of a geotechnical work (observation and monitoring).
7. Thesis Justification.
8. Writing and presentation of a work plan.

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### **Applied Geochemistry (GEO10093)**

1. Geochemistry as a geoscience to the study of interaction of geospheres.
2. Chemical equilibrium, Ions in solution and ionic mobility.
3. Oxide-reduction process: sedimentation and pH and Eh, Interpretation of Eh-pH diagrams, , the oxidation of the sulphites.
4. Geochemistry of weathering.
- 4.a. Weathering of the stone monuments: The main stones of Portuguese monuments, Main pathologies: characterization and diagnosis, examples.
5. Sorption and ionic exchange on the surface of minerals.
6. New Minerals: Precipitation-dissolution and stability, Retention of pollutant metals, Examples in wastes and landfills.
7. Hydro-geochemistry and transport of pollutants.
8. Potentially toxic metal geochemistry: Origins of metals (anthropogenic and natural), Mobility of metals in natural environments, Examples of "natural" pollution, the example of the mines and abandoned wastes.
9. Correction strategies.

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### **Building Materials (ERU12521)**

Aggregates.

Cement.

Lime.

Concrete.

Ceramics.

Natural stones.

Ferrous and nonferrous materials.

Plastics.

Timber.

Bitumen materials.

Paints



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### **Mining Technology (GEO7169)**

Theoretical

1 - Introduction

1.1 - General information

1.2 - Valuing phases of a mineral deposit

2 – Mining works cycle

2.1 - Introduction

2.2- Drilling

2.3 – Charging and Blasting

2.4 - Ventilation

2.5 - Scaling

2.6- Supported methods

2.7- Loading and transport

2.8- Water management and sediment control system

2.9- Electricity supply and compressed air system

3 – Underground mining methods

1-Open stopes; 2- Timbered stopes; 3- Filled stopes; 4- Shrinkage stopes; 5- Caving methods; 6- Combined methods

IV - Safety and Health in the mining industry. Accidents prevention and control.

V - Environmental risks from the mining industry

Practice

I - Mineral reserve calculation methods

II – Blasting project in galleries and tunnels

III – Pumping calculation

IV - Calculation of loading and transport cycles

V - Technical visits in principals underground portuguese mines. Internship if applicable.

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### **Environmental Rehabilitation (GEO7154)**

Introduction to the concepts of environmental rehabilitation and ecological restoration. The objectives, criteria, benchmarks of recovery.

Impacts due to mining, quarries and gravel pits. Correction of impacts related to noise and vibration.

Management of toxic and radioactive waste. Treatment of degraded areas.

Correction of impacts on water systems. Surface Water.

Rehabilitation of Aquifers.

Contamination of soils, sediments and water by heavy metals from mines. Decontamination of land.

Tailings dams.

Correction of impacts on air quality, soil, landscape and ecological systems.

Introduction to Environmental Geotechnics. Sustainable development.

Correction of impacts in Linear Works (road and rail).

Characterization and classification of waste management and waste disposal.

Management and recovery of waste in geotechnical works. Legislative framework for the recovery of waste.

Geological Storage of CO<sub>2</sub>.

Methods of environmental recovery of coastal and estuarine areas.



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### **Petrogenetic Processes (GEO12522)**

1. Igneous processes associated with the genesis and evolution of oceanic crust
  - 1.1 - Magmatism in divergent boundaries
  - 1.2 - Magmatism in convergent boundaries
  - 1.3 - Intraplate magmatism.
2. metamorphic processes associated with the evolution of oceanic crust
  - 2.1 - Hydrothermal vents
  - 2.2 - Oceanic metamorphism
  - 2.3 - Dynamic metamorphism
3. Igneous processes associated with the genesis and evolution of continental crust
  - 3.1 - Anorogenic magmatism
  - 3.2 - Orogenic magmatism
4. Metamorphic processes associated with the evolution of continental crust
  - 4.1 - Low-grade metamorphic belts
  - 4.2 - High grade metamorphic belts
  - 4.3 - Paired metamorphic belts

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### **Prospecting and abstraction of groundwater (GEO12523)**

Geophysical methods for prospecting and exploration of groundwater: Geoelectrics, VLF, Seismic, Gravity, Magnetic, Georadar.

Hydrogeology of Portugal. Use of different methods of prospecting according to the different types of aquifer.

Execution of wells. Methodology and appropriateness of the methodologies to real conditions of terrain and geology.

Flow tests and its importance for defining the hydraulic characteristics of aquifers and the establishment of exploitation rates.

Protection of groundwater and wells against pollution.

Type of wells and flow generated in them.

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### **Geotechnical works (GEO12524)**

Introduction. Definition of the concept of Geotechnical work. Methodologies of the geotechnical design.

Eurocode 7. Introduction to Eurocode 8 (aspects related to the geotechnical design under seismic conditions).

Types of Geotechnical works:

1. Foundations of buildings and other structures;
2. Retaining walls. Earth pressures. Gravity walls;
3. Hydraulic Works (dams, dykes, other river works, etc.);
4. Transportation Facilities (highways, railways, airports, airfields, canals, etc.);
5. Introduction to Embankment Works. Landfill Slopes. Compaction;
6. Underground Works (tunnels and cavities);
7. Maritime Works (harbours, oil rigs, coastal protection structures, etc.);
8. Geomaterials. Its use in building construction. New application perspectives. Site Improvement;
9. Introduction to Geosynthetics: classification, functions and applications
10. Study cases. Special Geotechnical works.