Study Plan

School: School of Sciences and Technology
Degree: Master
Course: Earth, Atmospheric and Space Science (cód. 441)

Specialization Meteorology, Climate and Environment

1st Year - 1st Semester
Specialization Meteorology, Climate and Environment

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10340M	Earth and Atmospheric Physics	Physics	6	Semester	156
FIS10341M	Solar and Planetary Physics	Physics	6	Semester	156
FIS10342M	Observation Methods and Tecniques in Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
FIS10343M	Signal Analysis and Inversion Methods	Physics	6	Semester	156
FIS10344M	Radiation, Clouds and Precipitation	Physics	6	Semester	156

1st Year - 2nd Semester
Specialization Meteorology, Climate and Environment

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10345M	Energy, Environment and Sustainability	Renewable Energy Engineering	6	Semester	156
FIS10346M	Computational Methods in Physics and Engineering	Physics	6	Semester	156
FIS10347M	Climate, Climate Modelling and Climate Change	Physics	6	Semester	156
QUI13041M	Atmospheric Pollution and Gas Effluents Emission	*** TRANSLATE ME: ***	6	Semester	156
FIS10348M	Remote Sensing and Environmental Satellites	Physics	6	Semester	156

2nd Year - 3rd Semester
Specialization Meteorology, Climate and Environment

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10349M	Synoptic Meteorology and Weather Forecast	Physics	6	Semester	156
FIS10350M	Athmosferical Boundary Layer Micrometeorology	Physics	6	Semester	156
FIS10351M	Seminar on Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
Dissertation					

2nd Year - 4th Semester
Specialization Meteorology, Climate and Environment

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

Last update 18/06/2019

Conditions for obtaining the Degree:

*** TRANSLATE ME: Área de Especialização em Meteorologia, clima e Ambiente: { \ } newline

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Para aprovação na componente curricular nesta área de especialização é necessário a provação (através de avaliação ou creditação) das seguintes unidades curriculares. { \ } newline

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1º Semestre: { \ } newline

5 UC Obrigatórias num total de 30 Ects { \ } newline

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2º Semestre: { \ } newline

5 UC obrigatórias num total de 30 Ects { \ } newline

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3º Semestre: { \ } newline

3 UC Obrigatórias num Total de 18 Ects { \ } newline

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Para obtenção do grau, é necessário também a aprovação em Dissertação, com o total de 42 ECTS, no 3.º e 4.º Semestre ***

Specialization Internal Geophysics

1st Year - 1st Semester
Specialization Internal Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10340M	Earth and Atmospheric Physics	Physics	6	Semester	156
FIS10341M	Solar and Planetary Physics	Physics	6	Semester	156
FIS10342M	Observation Methods and Tecniques in Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
FIS10343M	Signal Analysis and Inversion Methods	Physics	6	Semester	156
FIS10352M	An Introduction to Space Geodesy and Crustal Deformation	Physics	6	Semester	156

1st Year - 2nd Semester
Specialization Internal Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10345M	Energy, Environment and Sustainability	Renewable Energy Engineering	6	Semester	156
FIS10346M	Computational Methods in Physics and Engineering	Physics	6	Semester	156
FIS10353M	Seismology	Physics	6	Semester	156
FIS10354M	Applied and Environmental Geophysics	Physics	6	Semester	156
FIS10355M	Seismicity and Seismotectonics	Physics	6	Semester	156

2nd Year - 3rd Semester
Specialization Internal Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10356M	Geothermics	Physics	6	Semester	156
FIS10357M	Seismic Risk and Strong Ground Movements	Physics	6	Semester	156
FIS10351M	Seminar on Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
Dissertation					

2nd Year - 4th Semester
Specialization Internal Geophysics

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

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Specialization Environmental Instrumentation

1st Year - 1st Semester
Specialization Environmental Instrumentation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10340M	Earth and Atmospheric Physics	Physics	6	Semester	156
INF10358M	Programming and Intelligent systems	Informatics	6	Semester	156
FIS10342M	Observation Methods and Tecniques in Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
FIS10343M	Signal Analysis and Inversion Methods	Physics	6	Semester	156
FIS10359M	Instrumentation	Electrotechnical Engineering	6	Semester	156

1st Year - 2nd Semester
Specialization Environmental Instrumentation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10345M	Energy, Environment and Sustainability	Renewable Energy Engineering	6	Semester	156
FIS10346M	Computational Methods in Physics and Engineering	Physics	6	Semester	156
FIS10348M	Remote Sensing and Environmental Satellites	Physics	6	Semester	156
QUI13041M	Atmospheric Pollution and Gas Effluents Emission	*** TRANSLATE ME: ***	6	Semester	156
FIS10360M	Environmental Sensors	Physics	6	Semester	156

2nd Year - 3rd Semester
Specialization Environmental Instrumentation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10361M	Optoelectronics	Electrotechnical Engineering	6	Semester	156
INF10362M	Data Mining	Informatics	6	Semester	156
FIS10351M	Seminar on Earth, Atmospheric and Space Sciences	Physics	6	Semester	156

2nd Year - 3rd Semester
Specialization Environmental Instrumentation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

2nd Year - 4th Semester
Specialization Environmental Instrumentation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

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Para obtenção do grau, é necessário também a aprovação em Dissertação, com o total de 42 ECTS, no 3.° e 4.° Semestre. ***

Specialization Degraded Environments Rehabilitation

1st Year - 1st Semester
Specialization Degraded Environments Rehabilitation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
GEO10363M	Environmental Hydrogeology	Geology	6	Semester	156
GEO10093M	Applied Geochemistry	Geosciences	6	Semester	156
FIS10342M	Observation Methods and Tecniques in Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
QUI10364M	Environmental Chemistry	Chemistry	6	Semester	156
BIO10365M	Evaluation of the state of surface freshwaters	Biological Sciences	6	Semester	156

1st Year - 2nd Semester
Specialization Degraded Environments Rehabilitation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS10345M	Energy, Environment and Sustainability	Renewable Energy Engineering	6	Semester	156
GEO10366M	Biogeochemistry of aquatic sediments	Geology	6	Semester	156
QUI13041M	Atmospheric Pollution and Gas Effluents Emission	*** TRANSLATE ME: ***	6	Semester	156
GEO10080M	SIG Remote Sensing	Geology	6	Semester	156
FIS10354M	Applied and Environmental Geophysics	Physics	6	Semester	156

2nd Year - 3rd Semester
Specialization Degraded Environments Rehabilitation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
PAO10367M	Methods for the recovery of degraded areas	Environment and Ecology Sciences	12	Semester	312
FIS10351M	Seminar on Earth, Atmospheric and Space Sciences	Physics	6	Semester	156
Dissertation					

2nd Year - 4th Semester
Specialization Degraded Environments Rehabilitation

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

Conditions for obtaining the Degree:

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1º Semestre:{ \ } newline
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3º Semestre:{ \ } newline
2 UC Obrigatórias num total de 18 Ects{ \ } newline
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Para obtenção do grau, é necessário também a aprovação em Dissertação, com o total de 42 ECTS, no 3.º e 4.º Semestre. ***

Conditions for obtaining the Degree:

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1º Semestre:{\}newline

5 UC Obrigatórias num total de 30 Ects{\}newline

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2º Semestre:{\}newline

5 UC obrigatórias num total de 30 Ects{\}newline

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3º Semestre:{\}newline

3 UC Obrigatórias num Total de 18 Ects{\}newline

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Para obtenção do grau, é necessário também a aprovação em Dissertação, com o total de 42 ECTS, no 3.º e 4.º Semestre{\}newline

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Área de Especialização em Geofísica Interna:{\}newline

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Para aprovação na componente curricular nesta área de especialização é necessário a a provação (através de avaliação ou creditação) das seguintes unidades curriculares:{\}newline

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1º Semestre:{\}newline

5 UC Obrigatórias num total de 30 Ects{\}newline

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2º Semestre:{\}newline

5 UC obrigatórias num total de 30 Ects{\}newline

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3º Semestre:{\}newline

3 UC Obrigatórias num Total de 18 Ects{\}newline

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Para obtenção do grau, é necessário também a aprovação em Dissertação, com o total de 42 ECTS, no 3.º e 4.º Semestre{\}newline

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Earth and Atmospheric Physics (FIS10340M)

The Earth, planet of the solar system.

The shape of the Earth and the gravity field .

Introduction to Seismology.

Some comments about geophysical prospection.

Geomagnetism.

Introduction to paleomagnetism.

Introduction to the study of the heat flow from the Earth.

Composition and structure of the Earth's atmosphere.

Thermodynamics of the atmosphere: thermodynamic characteristics of dry and moist air. Thermodynamic processes in the atmosphere. Formation of dew, frost, fog and clouds. Statics of the atmosphere. The hydrostatic equation. Atmospheric stability. Clouds and precipitation.

Radiation: Earth radiation budget. Physical radiation laws of the blackbody. Radiation transmission in the atmosphere. Absorption. Emission and scattering. Radiative transfer equation. Greenhouse Effect. Aerosol effects. Radiative forcing.

Atmospheric dynamics: Fundamental forces in the atmosphere. Equations of fluid motion. The general

circulation of the atmosphere.

Solar and Planetary Physics (FIS10341M)

(I) Astrophysics and the Universe:

(i.1) Introduction. Basic Concepts in Astronomy and Astrophysics.

(i.2) Formation and Evolution of our Universe.

(II) - Physics of the Sun

(ii.1) Introduction to the structure of the Sun,

(ii.2) Atmosphere of the Sun

(ii.3) Internal structure of the Sun,

(ii.4) Theory of helioseismology

(ii.5) Comments in helioseismology

(ii.6) Evolution of the Sun as a star,

(ii.7) Solar Neutrinos,

(ii.8) Sun-Earth Interaction

(ii.9) the Solar System: the Sun and its evolution.

(III) The solar system and its constituents:

(iii.1) The planets of the solar system

(iii.2) Other constituent bodies of the solar system,

(iii.3)The spatial distribution of bodies in the solar system

(iii.4) The dynamics of the solar system.

(IV) Planetary formation and evolution:

(iv.1) Formation of the Solar System: The solar disk,

(iv.2) Formation of the Solar System and the conservation of angular momentum. Formation of the Solar System and the origin of planets and asteroids.

Observation Methods and Tecniques in Earth, Atmospheric and Space Sciences (FIS10342M)

Study of different remote sensing ground based instruments and their physical priciples (RADAR,LIDAR, Spectroscopy, Photometry, Interphotometry). Satellite remote sensing sensors. Physical principles of remote sensing. Passive and active systems. In situ monitoring systems. Meteorological instruments and radiosounding systems. GPS. Seismometers, gravity meters, magnetometers. Global observation network. Observation, interpretation and record of distinct geophysical field data found in different places.

Signal Analysis and Inversion Methods (FIS10343M)

Digital signal processing and inversion methods - Analysis of discrete and continues time series. Applications of multivariate analysis to geophysics and climate. Principles and techniques of signal treatment geophysics and climate. Fast Fourier Transforms (FFT), Z transforms Laplace transforms. Deconvolution, fileter design and transfer function. Spectral analysis. Inverse problem in geophysics and Atmosphere.

Methods of linear and non linear inversion. Problem of non-unicity; Analysis of data and model resolutions. Applications.

Radiation, Clouds and Precipitation (FIS10344M)

Fundamentals of Radiation and of electromagnetic wave propagation in a free space. Extinction of solar and infrared radiation through the atmosphere. Main absorbers and scatters in the atmosphere Rayleigh scattering and Mie theory. Transfer radiative equations and models in plane-parallel atmospheres. Radiation and Climate.

Cloud formation processes. Nucleation of water and ice nuclei. Cloud growing processes. Formation of precipitation. Modification processes of clouds. Electrification mechanisms within clouds.

Energy, Environment and Sustainability (FIS10345M)

1. The energy problem worldwide.
2. The concept of sustainability in the context of Energy.
3. Energy and Competitiveness.
4. The energy markets.
5. Energy and Environment.
6. Energy, emissions of greenhouse gases and climate change.
7. "Lyfe Cycle Assessment" of energy projects

Computational Methods in Physics and Engineering (FIS10346M)

1. Introduction - The actual paradigm in computation, computational algorithms and languages, computational arithmetic
2. Basic numerical methods - operation with matrix, differentiation and integration, interpolation, nonlinear equations, systems of linear equations, systems of nonlinear equations, approximation of functions
3. Differential equations - Ordinary differential equations and partial differential equations
4. Modelling of continuous systems - diffusion equation, wave equation and hydrodynamic equations
5. Spectral analysis - continuous Fourier transform, discrete Fourier transform, FFT, determination of spectral energy density
6. Optimization and inversion - Linear programming, quadratic, nonlinear and integer; linear and nonlinear inverse problem, least square method, Baysian formulation of inverse problem, a priori information, analysis of resolution and errors.

Climate, Climate Modelling and Climate Change (FIS10347M)

The Climate system. Spatio-temporal scales; non-linearity and feedbacks; climate variability and predictability; brief history of the climate; palaeoclimatology.

The Observed general circulation of the atmosphere and the oceans; The global cycles of energy, angular momentum, water and carbon dioxide, quasi periodic oscillations and teleconnections.

Radiation and radiative forcing; gases, aerosols, clouds and radiation in the atmosphere, radiative transfer models. The greenhouse effect of the atmosphere.

Climate change. Climate change detection and attribution of causes; Observations on the surface, atmosphere, oceans and cryosphere

Climate models; Energy balance models, general circulation climate models and its components; Evaluation and validation of climate models

Scenarios of future climate. Downscaling of future climate scenarios

Atmospheric Pollution and Gas Effluents Emission (QUI13041M)

Air pollutants and its action. Strotospheric ozone. Photochemical smog. Acid rain. Air particles in suspension. Volatile organic compounds. Greenhouse effect gases. Metals and metalic compounds. Air pollutants monitoring. Environmental laws. Standard methods for monitoring the main air pollutants. Methods for gaseous emission treatment. Gravity settlers. Cyclones. Electrostatic precipitators. Filtration. Washers. Dispersion of pollutants in the atmosphere. Elements of atmospheric physics and dynamics. Atmospheric circulations and the transport of pollutants. Atmospheric Boundary Layer and Turbulence. Air pollution dispersion models.

Remote Sensing and Environmental Satellites (FIS10348M)

Radiation basics. The problem of inversion in remote sensing: inversion of the radiative transfer equation. Radiative transfer models - medium and high spectral resolution (MODTRAN, HITRAN, 6S, STREAMER, RSTAR,LibRadtran). Environmental Satellites as systems to observe the Earth and respective applications: detection and characterization of clouds, aerosols and gases, temperature and humidity profiles in the atmosphere, characterization of surface waters, physical characterization of different types of surfaces. Problematics associated with the calibration and validation. Interpretation of meteorological satellite imagery. Satellite imagery processing software is explored.

Synoptic Meteorology and Weather Forecast (FIS10349M)

The general circulation of the atmosphere and the scales in meteorology. Global meteorological observations and synoptic weather charts. Structure and evolution of the main synoptic weather systems.

Synoptic meteorology equations: The fundamental equations of the atmospheric motions; scale analysis and approximations; circulation and vorticity; the vorticity equation;

The quasi-geostrophic approach and the extra-tropical circulations; Diagnosis of the vertical motion.

Introduction to numerical weather prediction: historical aspects of weather forecasting; methods of discretization and numerical integration of the equations.

Parametrization and representation of sub-scale physical phenomena in NWP models: turbulence, clouds and precipitation, radiation, surface-atmosphere interaction.

Data assimilation and meteorological analysis. Predicatbility and Probabilistic prediction.

Nowcasting and
Very Short Term Forecasting

Athmosferical Boundary Layer Micrometeorology (FIS10350M)
1. Introduction
2. Energy balance at the Earth's surface
3. Surface water balance.
4. Basic atmospheric equations.
5. Parameterisation of turbulent fluxes of momentum, energia and mass in the atmospheric inertial sublayer- K-closure of the governing equations for the ABL. Mean profiles and similarity in a stationary and horizontally-uniform ABL. The logarithmic profile law in the neutral inertial sublayer. Monin- Obukhov flux-profile relations for the (non-neutral) inertial sublayer. The universal functions, or stability correction functions. The surface roughness parametres. The zero-plane displacement length, and roughness lengths for momentum, energy and mass transfer.
6. Methods for estimating the surface fluxes - Eddy-correlation method. Bowen ratio method. Profile method. Flux-variance methods. Others.
7. Air Pollution- Atmosferic stability, diffusion and transport. Gaussian plume models.
8. Climates of Non-homogeneous Terrain- Flux divergence due to spatial variability.

Seminar on Earth, Atmospheric and Space Sciences (FIS10351M)
Due to the specific objectives of this course content will vary from year to year, influenced mainly:
1) by the partnerships supported by scientific research projects where students are integrated as part of the project;
2) by seminars and national and international conferences.
However, the program will provide advanced knowledge in the areas of Earth, Atmosphere and Space Sciences, in particular in the following areas: Synoptic Meteorology and Weather Forecasting; Climate, Climate Variability and Climatic Change; Observation systems, detection and monitoring techniques of the atmosphere and space; Solar and Planetary Physics; Seismology and seismic risk; Geophysical Prospecting; Genesis and dynamics of geological materials; Mineral resources; Environmental impacts; Genesis and dynamics of geological materials; Distribution of geological materials at the superficies of the Earth.

An Introduction to Space Geodesy and Crustal Deformation (FIS10352M)
1. Elastic and viscoelastic models that explain the crustal deformation: seismic cycle; deformations of the continents; kinematics of the lithospheric plates

2 Operating means of calculus
a) Tensor calculus
b) Stress tensor and properties
c) Tensor of the deformations and properties
d) Relations between stresses and strains in isotropic materials

3. Mechanics of earthquakes
a) Models of rupture;
b) Quantification of the source
c) Relations of scale

4. Analytical and numerical models of crustal deformation
a) analytical Okada formulas for point-source situations
b) analytical and numerical methods for modeling the deformation produced by finite sources (EDMC and Coulomb programs)

5. Techniques based on space geodesy to measure the deformation: global positioning system (GPS) and differential radar interferometry (DInSAR)

6. Modeling of surface deformation associated with a published source model of a recent earthquake. The results will be compared with GPS or InSAR registered data

Seismology (FIS10353M)
1) Complements of continuum mechanics.
2) Equations of motion.
3) wave propagation inside the Earth.
4) Internal waves, surface waves.
5) inelasticity and anisotropy.
6) Earth eigenmodes.
7) Seismic Source.
8) synthetic seismograms.
10) Analysis of seismic data.

Applied and Environmental Geophysics (FIS10354M)
I - Introduction
II - Electrical methods
III - Gravimetric methods
IV - Seismic methods
V - Well logging

Seismicity and Seismotectonics (FIS10355M)
1) Seismicity and seismotectonics - Introduction
2) Theory of plate tectonics.
3) Global Seismicity.
4) Earthquakes and plate boundaries (convergent, divergent and transform boundaries)
5) Intra-plate seismicity.
6) Seismic cycle.
7) Seismic rupture, seismic deformation and the stress field.
8) Seismicity and Seismotectónics of Azores and Iberian-Magrebinan area

Geothermics (FIS10356M)
Introduction. The Earth as a heat source. Heat transfer.
Heat flow through ocean regions. Cooling of the Oceanic Lithosphere. Heat loss through the oceanic bottom.
Heat flow through continental regions and mean heat flow value. Estimates of Moho heat flow values. Recently active regions. Continental margins. Heat flow from the Mantle.
Heat sources. Radioactive elements. Heat flow from the Core. Other sources.
Secular cooling. The present-day Mantle Geotherm. Temperature versus age of the Earth. Magma Ocean evolution. Average secular cooling rate.

Utilization of the Internal heat of the Earth. Electricity production. Direct utilization of geothermal fluids. Geothermal heat pumps. Geothermal energy use in Portugal.

Seismic Risk and Strong Ground Movements (FIS10357M)
Earthquake Physics; seismicity; seismic wave propagation; attenuation. Probabilistic and deterministic models of earthquake occurrence; precursor effects. Instrumentation of strong ground motion and data interpretation. Spatial and temporary characterization of the components of the seismic motion; site effects. Seismic Zoning. Seismic hazard, vulnerability and seismic risk. Deterministic, empirical and stochastic modelling of strong ground motion. Construction of seismic sceneries; seismic hazard and seismic risk in Portugal.

Programming and Intelligent systems (INF10358M)
1. Object oriented programmig paradigm. Data structures. Flow Control instructions. Control and monitoring systems application.
2. Graphical user interfaces - Instrument Data logging, data transmission to instruments, PLCs and computers. Data presentation; time series, andn alarm settings. . Recebimento de ordens provenientes de um utilizador humano através da interface gráfica. Data processing.
3. Control and automation. - Application to control an d automation processes of production processes.

Instrumentation (FIS10359M)
Introduction to Metrology: History, Definition, Units and fundamental laws of physics. Notion of uncertainty and error propagation law of errors and uncertainties. Application to experimental data. Curve fitting by the least squares criterion.
Transducers measure: Definition, Physical Principles, Applications. Classifications of the measurement transducers.
Electrical analogue instruments: galvanometer, voltmeter, ammeter, ohmmeter, wattmeter, phase meter, oscilloscope, etc. ...)
Measurements of electrical quantities (voltage, current, resistance, impedance, etc ....)
Measurement of quantities other than electrical: displacement, velocity, force, temperature ...)
Geophysical measurements and environmental parameters.
Introduction to digital instrumentation.
Signal processing algorithms: DFT, FFT, Adaptation of models.

Environmental Sensors (FIS10360M)
Main environmental quantities that should be monitored. International System of Units.
Transducers for mechanical, thermal, electric, magnetic, radiation and chemical quantities. Optical or electrical signal acquisition and processing; data transmission and storage. Considerations about the most frequently used sensors. Physical principles of the sensors that are part of the satellite and surface based, earth observation systems. Automatic calibration, digital image acquisition and transmission.
Sensitivity and precision. Sampling problems.

Optoelectronics (FIS10361M)
1. Introduction to optoelectronic systems.
2. Light sources: LEDs and LASERS (gas and solid state). Noise and coherence.
3. Optical detectors: photodiodes, phototransistors, photoconductors. Silicon array sensor: CCDs, photodiodes arrays.
4. Lenses, prism and mirrors.
5. Light polarization, matter interaction and birefringence.
6. Diffraction gratings, holography, converters and electro-optic modulators.
7. Optical fibers.
8. Optical measurements.
9. Construction of optical systems and design of electronic subsystems.
10. Photovoltaic energy systems.

Data Mining (INF10362M)
1. Introduction: Machine learning and data mining
2. Classification problems
3. Naive Bayes
4. Decision trees
5. Instance based algorithms
6. SVM
7. Input: concepts, instances e attributes
8. Output: knowledge representation
9. Performance evaluation
10. Data Processing for "knowledge discovery"
11. Clustering
12. Data association
13. Visualization
14. Applications

Environmental Hydrogeology (GEO10363M)
Rational exploitation, over-exploitation, methods of contamination and protection of aquifers against contamination. Wellhead protection areas. Remediation measures in aquifers. Remediation of groundwater contaminated with metals. Remediation of hydrocarbons, volatile or nonvolatile, dense or light. Remediation of organic contaminants, chlorinated solvents, sulfates, nitrates and other contaminants. Methodologies used for treatment of groundwater, bioremediation, oxidation/reduction chemistry, in situ flushing, air sparging, permeable reactive barriers, electrochinectics, thermal methods, steam, treatment by UV/oxidation, horizontal holes, vertical circulation holes, hydraulic and pneumatic fracturing applied to groundwater remediation, stabilization/solidification, natural attenuation, etc. .. Interaction groundwater/surface water. Methodology for identification and their importance in the hydrological cycle. Groundwater-dependent ecosystems. Methodology of identification.

Applied Geochemistry (GEO10093M)
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 stomes 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.

Environmental Chemistry (QUI10364M)

1. Introduction
1.1 General concepts
1.2 Pollution and environmental problems. Pollution natural versus anthropogenic pollution

2. Water and wastewater
2.1 Water pollution. Surface and ground waters. Water quality and analysis methods
2.2 Main legislation
2.3 Characterization of water and wastewater: physical, chemical and biological parameters
2.3.1 Physical
2.3.2 Chemical
2.3.3 biological

3. Water and wastewater treatment
3.1 Treatment of water for human consumption
3.2 Process water treatment plants (WWTP)

4. Recovery and solid waste treatment
4.1 The solid waste management. National legislation
4.2 Recycling
4.3 Composting
4.4 Anaerobic digestion
4.5 Energy recovery (Incineration)
4.6 Confinamento (Aterros sanitários)

5. Soil Chemistry

6. Remediation of contaminated soils and food security

7. Phytoremediation of soils and waters

8. Most common pollutants in the environment: mobility and fate

Evaluation of the state of surface freshwaters (BIO10365M)

1. Freshwater ecosystems diversity. Consequences of climate, hydrology and scale
2. Running water. Consequences of flow in running waters. Physical, chemical and biological processes. Longitudinal, lateral and vertical connectivity. Spatial and temporal scales.
3. Standing waters. Consequences of depth and water circulation in standing waters. Physical, chemical and biological processes. External and internal sources of nutrients. Natural and cultural Eutrofication.
4. Wetlands. Ectone concept. Physical, chemical and biological processes.
5. Status of superficial water bodies' and Water Framework Directive (WFD)
6. Evaluation of ecological status/potential; evaluation of chemical status. Classification systems for quality elements
7. Degradations causes. Objectives and measures at water bodies scale and at basin scale
8. Sampling and monitoring programmes: objectives and results

Biogeochemistry of aquatic sediments (GEO10366M)
Biogeochemistry of aquatic systems: Introduction
River Sediments: Characteristics of rivers, Material flows through rivers, Chemical fluxes and dynamics of rivers.
Lacustrine sedimentation in artificial systems: The natural erosion and accelerated erosion of soils in the watersheds of the lake systems, Physical and chemical processes in lake systems, Dams and reservoirs and nutrient cycles, Factors controlling the transport of materials and sedimentation in dams, Transport and sedimentation of materials, Mechanisms of Transport and Deposition of Clay Minerals, Chemical fluxes and dynamics of lakes.
Biogeochemistry of river and lake sediments: major elements (Ca, Mg, Na, K, Na), metallic elements, trace metals, nitrogen, phosphorus, carbon, methane, redox potential.
Pollution and remediation of aquatic systems: Acidification, Pollution by pathogens and toxins, Eutrophication, The redox potential and recovery of lakes, Dredging as a recovery technique.

SIG Remote Sensing (GEO10080M)
GIS and the sciences.
Graphical representations; Projection Systems; Georeferencing; Scanning information.
- Computer georeferenced data.
- Aerial and satelite photography, princíples of acquisition and treatment of images.
- Ortorectified and stereoscopic images.
- Symbols and Labels in GIS
- Creation of Layouts:
- Scanning of points and lines.
- Creating and editing symbols
- Layer Files type.
- Georeferencing:
- Digitizing polygons
- Creating layouts
- Use of images from Google Earth for the recognition of human, geographic and geological structures.
- Use of Landsat 7 images for terrain characterization. The algoritmes for NDVI, clays and iron oxides.
- Small GIS project.

Methods for the recovery of degraded areas (PAO10367M)
1. Introduction to the concepts of rehabilitation and containment of degraded areas - objectives, criteria and rehabilitation targets
2. Impacts due to mining and other activities (industry or military). Treatment in degraded areas
3. Correction of impacts of superficial water systems
4. Rehabilitation of aquifers
5. Soil, sediments and water contamination. Corrective measures.
6. Correction of impacts on air, soil, landscape and ecological systems.
7. Project.