Master Program on
«ENVIRONMENTAL SCIENCES AND ENGINEERING»

COURSES OUTLINE AND DIPLOMA THESIS

COURSES OUTLINE IN ENGLISH

SEMESTER A

EMP50 -ENVIRONMENTAL CHEMISTRY AND PHYSICS - CLIMATE CHANGE

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**EMP50**	**SEMESTER**	**WINTER**
COURSE TITLE	ENVIRONMENTAL CHEMISTRY AND PHYSICS - CLIMATE CHANGE		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and training experiments	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge, skills development
PREREQUISITE COURSES:	Basic knowledge of analytical chemistry, organic chemistry, and physical chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and English depending on the trainees
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES in English
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST110/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- The aim of the course is to present the environmental processes that affect the composition of the atmosphere and the climate of our planet, with emphasis on the physico-chemical processes that take place in the atmosphere and their impact on climate, ecosystems and humans.
- The course also aims to highlight the connection between the atmosphere, oceans, land and vegetation through energy and mass fluxes (of different chemical composition and physical characteristics), which are crucial for the quality of the atmosphere and the climate of our planet.
- Students should acquire the ability to critically search and consult the scientific literature on Earth Science.
- Students should acquire the ability to present a summary of a scientific article related to the environment and climate change in an interesting and scientifically correct way.
- Students should be able to present a summary of an environment and climate change related scientific article in an interesting and scientifically sound manner.

- Student will also learn to work as a team.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Team work
- Working in an interdisciplinary environment
- Decision -making
- Project planning and management
- Respect for the natural environment
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

Module I

Structure of the atmosphere, Chemical composition of the atmosphere, Radiation balance (blackbody, absorption, radiation emission, the greenhouse effect), Changes in Earth's climate - clues, Atmospheric circulation (Mixing layer, Temperature inversion, Sea and continental breezes, general circulation, Hadley's cycles, high low barometric, fronts, precipitation, true winds, monsoons, stratospheric/tropospheric exchanges, monsoons, Valley, Southern Oscillation).

Module II

Marine Circulation, interactions between atmosphere and sea, Ekman's spiral, deep water formation, marine layers, currents, upwelling. The water cycle and climate. Cloud formation and types of clouds.

Module III

Carbon cycle (carbon dioxide) and climate, Greenhouse effect. Air pollutants with climate impact. Milankovich cycles. Carbon, oxygen and sulphur isotopes, use of isotopes to understand and date processes in the environment

Module IV

Stratospheric chemistry, Chapman mechanism, Catalytic cycles for stratospheric ozone destruction (active hydrogen, nitrogen and halogen cycles). Storage compounds and cycle coupling. Stratospheric observations and predictions. The ozone hole (Arctic and Antarctic). Polar stratospheric clouds. Heterogeneous reactions in non-polar regions of the stratosphere. ODP of halogenated compounds. Supersonic effect of airplanes. The Junge layer and COS.

Module V

Tropospheric Chemistry: Ozone/NOx/CO, B. Ozone balance and the role of nitrous oxides, C. Free radicals : OH and NO3, D. CH4, E. Anthropogenic NMVOCs, F. Biogenic NMVOCs, H. Nitrogen cycle, I. Sulphur cycle, I. Halogenated compounds, K. Liquid phase in the troposphere, Henry's Law Equilibria between liquid and gas phases in the troposphere, Liquid phase reactions, Air - sea

exchanges, L. Particulate phase in the troposphere, Physical properties, Characterization, Chemical composition, Atmospheric distributions in different parts of the troposphere, M. Photochemical particle production, N. Heterogeneous reactions at the surface of suspended particles. O. Atmospheric Acidity.

Module VI

Impacts of air pollution on Health and on ecosystems.

Satellite observations of the Earth and its Atmosphere.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	All lectures will be given in the classroom and activities will be conducted face-to-face. Remote teaching will only be resorted to in exceptional cases.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	*Semester workload*
Lectures (18 lectures 4 hrs)	72
Assignments (4 assignment literature research)	32
Student Presentations (preparation and presentation time)	30
2 written Exams (mid-term, end-exam time + study time = 2x 30 h)	60
Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Study duration in weeks =14)	56
Total hrs	250
ECTS (25 hrs / ECTS)	10
Course total ECTS	***10***

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student evaluation in GREEK or ENGLISH

Type of Evaluation	**Points per evaluation**
Home assignments	4 home assignments x 5 points per assignment = 20 points
Student presentation	1 presentation = 30 points
Written Exam	2x 25 points = 50 points
	Total = 100 points

Students will be instructed on how to perform literature research and their assigned work as well as how to best make their presentations.

Assignments: will include an in-depth study of the functioning of the Earth system with an emphasis on chemical processes which will then be discussed in the group.

Presentations: Students will choose a recent research topic that is relevant to the course from the international literature, i.e. a research paper published in the last 5 years, and present it in a brief 20-minute presentation.

	Grading: Rubrics will be provided for each graded assignment. Final Exam: The final exam will contain multiple-choice questions that will cover the topics of the lectures and the discussed assignments, as well as a number of topics to develop that will enable the evaluation of the acquired knowledge by the students.

(5) ATTACHED BIBLIOGRAPHY

1. Σημειώσεις μαθήματος διαθέσιμες στο eclass
2. Atkinson R, Evaluated kinetic and photochemical data for atmospheric chemistry: Volume I – gas phase reactions of Ox, HOx, NOx and SOx species, Atmos. Chem. Phys., 4, 1461–1738, 2004 (kinetic data) & 2005
3. Barry, R. G. and Chorley, R. J. (1998) Atmosphere, weather and climate. Routledge, London, Great Britain.
4. Bernninkmeijer C.A.M., et al., Nature, 356, 50-52, 1992.
5. Duplessy J-C, and Morel P., (1990) Gros temps sur la planete, Editions Odile Jacob, 15 rue Soufflot 75005 Paris.
6. Falkowski P. et al., (2000) The Global Carbon Cycle: A Test of Our Knowledge of Earth as a System, Science 290, 291-296.
7. Finlayson-Pitts, B. J. (2003) The Tropospheric Chemistry of Sea Salt: A Molecular-Level View of the Chemistry of NaCl and NaBr, Chemical Reviews, 10.1021/cr020653t
8. Finlayson-Pitts B.J., Pitts, J.N., Jr., (2000) Chemistry of the Upper and Lower Atmosphere, Academic Press.
9. Graedel, T. E. and Crutzen, P. J. (1993) Atmospheric change: an Earth system perspective. W. H. Freeman and Company, New York, USA.
10. Grant W. Petty, A first Course in Atmospheric Radiation, Sundog Publishing, Madison Wisconsin.
11. Jacobson M.Z., Fundamentals of Atmospheric Modeling, Cambridge Univ. Press, 1999.
12. Jacob D., Introduction to Atmospheric Chemistry, Princeton University Press, 2000
13. Joussaume S., Climat d'hier a demain, Science au present, CNRS edition/CEA, 1993.
14. Legrand M., Jouzel, J., Raynaud, D, (1994) Past climate and trace gas content of the atmosphere inferred from polar ice cores, Chapter XXI, ERCA, Topics in Atmospheric and interstellar physics and chemistry, edited by C. F. Botron, published by Les editions de Physique, 453-477.
15. Lowe D. C. et al., Nature 332, 522-525, 1988.
16. Platt, U., Hoenninger, G. (2003) The role of halogen species in the troposphere, Chemosphere, 52, 325–338.
17. Platt U., Moortgat G.K. (1999) heterogeneous ad Homogeneous Chemistry of reactive Halogen Compounds in the Lower troposphere, J. Atmospheric Chemistry, 34, 1-8.
18. Seinfeld J., Pandis, S, Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, Wiley-Interscience eds, 2006.
19. Spyro, Th G, & Stigliani W. M., Chemistry of the Environment, Porentice Hall, Pearson Education LTD, 2003.
20. Wayne, P., Chemistry of Atmospheres, Oxford Science Publications (2000).
21. Wells, N. (1997) The atmosphere and ocean, John Wiley and sons, New York, USA.
22. Williams J., (1997) The Weather Book, USA TODAY, Vintage Books, A division of Random House inc., New York.
23. IPCC reports: http://www.ipcc.ch
24. https://ozonewatch.gsfc.nasa.gov/
25. https://csl.noaa.gov/assessments/ozone/2022/ Scientific Assessment of Ozone Depletion. WMO reports, Geneva
26. https://csl.noaa.gov/assessments/ozone/2022/twentyquestions/ Twenty Questions and Answers about the Ozone Layer.

EMP51-MODERN METHODS FOR ENVIRONMENTAL ANALYTICAL CHEMISTRY AND BIOANALYSIS

(1) GENERAL

SCHOOL	SCHOOL of SCIENCES & ENGINEERING		
ACADEMIC UNIT	Department of Chemistry		
LEVEL OF STUDIES	Graduate		
COURSE CODE	**EMP51**	**SEMESTER**	**winter**
COURSE TITLE	MODERN METHODS FOR ENVIRONMENTAL ANALYTICAL CHEMISTRY AND BIOANALYSIS		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
courses		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialised		
PREREQUISITE COURSES:	Organic Chemistry, Analytical Chemistry, Environmental Chemistry, Physical Chemistry		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	✓ Greek. ✓ English if Erasmus students take the course		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST106/		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The objectives of the postgraduate course MODERN METHODS FOR ENVIRONMENTAL ANALYTICAL AND BIOANALYTICAL CHEMISTRY (EMP…), "Mass Spectrometry & Chromatographic Techniques: Theory and Applications in Environmental Chemical Analysis & Bioanalysis", are:

1) To consolidate the basic principles of Mass Spectrometry and Chromatography,

2) To present the modern instrumentation of Mass Spectrometry, Chromatography, and Mass Spectrometry - Hyphenated Chromatographic Techniques for Environmental Analysis & Bioanalysis

3) To acquaint postgraduate students with the identification of chemical structures and quantitative determination in complex matrices with combined techniques of Mass Spectrometry and Chromatography.

4) To practice with the applications of Mass Spectrometry-Chromatography techniques in Environmental Analysis and Bioanalysis:

- ✓ Gas Chromatography/Mass Spectrometry (GC/MS)

- ✓ Liquid Chromatography/Mass Spectrometry (LC/MS)
- ✓ Inductively Coupled Plasma Mass Spectrometry (ICP/MS) and for comparison X-ray Fluorescence (XRF).

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas

(3) SYLLABUS

1 <u>Mass Spectrometry</u>

- ✓ <u>Theory of Mass Spectrometry</u>

- ✓ <u>Basic instrumentation of modern Mass Spectrometry</u>:
- Vacuum System
- Sample Introduction Devices: Direct introduction; Sample introduction from chromatography (GC & LC)
- Ion Sources and Ionization Techniques – Theory and Operation: Electron Impact (EI); Chemical Ionization (CI); Electrospray Ionization (ESI); Matrix Assisted Laser Desorption Ionization (MALDI);
- Mass Analyzers & separation of charged masses (ions) – Theory and Operation: Double Focusing (Sector) Analysis; Quadrupole Mass Analyzer (Q; full scan and selected ion monitoring); Tandem Mass Spectrometry; Ion Trap; Orbitrap; Time-of-flight (TOF); Combinations (ESI-TOF; TOF-MALDI; Q-TOF); Inductively Coupled Plasma Mass Spectrometry (ICP-MS); Resolution of Mass Analyzers

- ✓ <u>Detection of Ions</u>

- ✓ <u>Mass Spectra</u>:
- Interpretation of Mass Spectra – Theory and applications
- EI mass spectra
- CI mass spectra
- ESI mass spectra

- ✓ <u>Special seminars of Mass Spectrometry</u>:
- Analysis of Organic compounds (EI-MS; CI-MS; ESI-MS)
- Analysis of Biomolecules (ESI-MS) (proteomics)
- ✓ Elemental Analysis (ICP-MS) & X-ray Fluorescence (XRF).

- ✓ <u>Applications of Mass Spectrometry – Hyphenated Chromatographic Techniques in Environmental Analysis</u>:
- Analysis with GC-tandem MS of polycyclic aromatic hydrocarbons (PAHs) and persistent organic pollutants (POPs) in the atmosphere

- Analysis of drinking water disinfection by-products with GC-EI/CI-MS and LC-ESI-MS
- Determination and separation of bisphenol A, phthalate metabolites and structural isomers of parabens in biological liquids with LC-ESI-tandem MS
- Analysis of atmospheric particle-bound trace metals with ICP-MS
- Bioanalysis-Metabolomics.

✓ Applications of Mass Spectrometry techniques for real time environmental analysis:

- PTR-MS (Proton Transfer Reaction – Mass Spectrometry) the benchmark method for simultaneous real-time monitoring of volatile (organic) compounds (VOCs)
- Aerosol Mass Spectrometry (AMS) for the determination of the chemical composition of aerosols and in particular for components in ultrafine particles.
- Chemical Ionisation Mass Spectrometry (CIMS), for the determination of compounds of atmospheric interest.

2 Chromatography

- ✓ Basics, theory and types of separation
- ✓ Basics, theory and types of chromatography
- ✓ Gas-chromatography
- ✓ Liquid-chromatography
  - Normal phase HPLC
  - Reverse phase HPLC
- ✓ Separation modes in IC
- ✓ Qualitative and quantitative analysis in HPLC

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	All lectures will be given in the classroom and visits-demonstrations will be conducted in the mass spectrometry instrument laboratories (all face-to-face). Remote teaching (on ZOOM platform) will only be resorted to in exceptional cases.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	*Semester workload*
Lectures & exercises (24 lectures 4 hrs)	96
Assignments: Bibliographic research	30
Student Presentations (preparation and presentation time)	24
Final Exam (exam time + study time)	44
Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Course duration in weeks =14)	56
TOTAL HOURS	**250**
ECTS (25 hrs/ECTS)	**10**

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	**Examination** ✓ Written Examination (70% of total grade) ✓ Presentation of bibliographic research (30% of total grade) Delivery of exercise solutions after the completion of the syllabus (without grading)

(5) ATTACHED BIBLIOGRAPHY

In addition to the notes and references provided during the course presentation, students can also access specialized textbooks in the University of Crete's library and on the internet.

Proposed Books:

1) J. Throck Watson, O. David Sparkman, "Introduction to Mass Spectrometry: Instrumentation, Applications and Strategies for Data Interpretation", ISBN:9780470516348 |Online ISBN:9780470516898 |DOI:10.1002/9780470516898
2) R. Ekman, et al. "Mass Spectrometry: Instrumentation, Interpretation, and Applications", Wiley, ISBN: 978-0-471-71395-1
3) Handbook of Advanced Chromatography/Mass Spectrometry Techniques, Edited by: M. Holčapek and W. C. Byrdwell, Academic Press, ISBN: 978-0-12-811732-3

Proposed Sites:

https://masspec.scripps.edu/learn/ms/

https://chem.libretexts.org/Courses/Purdue/Purdue%3A_Chem_26200%3A_Organic_Chemistry_II_(Wenthold)/Chapter_11%3A__IR_and_Mass_Spectrometry/11.06%3A_Introduction_to_Mass_Spectrometry

EMP54- STATISTICAL TOOLS FOR DATA ANALYSIS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**EMP54**	**SEMESTER**	**WINTER**
COURSE TITLE	STATISTICAL TOOLS FOR DATA ANALYSIS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and Laboratory Exercises	4	10

Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	special background, specialised general knowledge, skills development	
PREREQUISITE COURSES:	Analytical Chemistry	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek or English depending on the students	
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES	
COURSE WEBSITE (URL)		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- The aim of the course is to introduce the student to the analysis of environmental data from laboratory experiments, measurements in simulation chambers, in the field and from numerical simulations, multi-factor analysis, identification of trends and sources of pollution.
- Introduction to statistical tools to determine correlations between environmental variables and to calculate source apportionment analysis.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search, analysis and synthesis of data and information, using the necessary technologies
-Working independently
-Team work
- Decision-making
- Promotion of free, creative and inductive thinking

(3) SYLLABUS

INTRODUCTION TO STATISTICAL ANALYSIS

Analytical problems

Errors in quantitative analysis

- Types of errors
- Propagation of errors
- Significant digits
- Computers in statistical calculations

APPLICATIONS OF STATISTICS TO REPEATED MEASUREMENTS
- Mean and standard deviation
- The distribution of repeated measurements
- Normal and logarithmic distribution
- Confidence intervals

EXPERIMENTAL TESTING (a)
- Comparison of results with theoretical values
- Comparison of results with other results
- t-test
- F-test

EXPERIMENTAL TESTING (b)
- Suspicious outlier and unacceptable value
- Analysis of price variance
- ANOVA calculations
- The statistical criterion χ2 (chi-square)

QUALITY CONTROL OF ANALYTICAL MEASUREMENTS
- Sampling and influence on the quality of results
- Separation of variances using ANOVA
- Design of sampling strategy
- Introduction to quality control methods
- Shewahart charts

STATISTICAL CALIBRATION METHODS IN INSTRUMENTAL ANALYSIS
- Calibration curves in instrumental analysis
- Regression analysis, linear correlation and least squares method
- Errors in regression analysis and unacceptable values
- Detection limits
- Addition of a reference sample
- Comparison of analytical techniques using regression
- Non-linear regression

NON-PARAMETRIC STATISTICS
- Applications of statistics to a small number of data
- The median and quartiles
- Box-and-whisker chart
- Non-parametric regression
- U-test
- Kolmogorov-Smirnov method

MULTIVARIATE ANALYSIS
- Cluster analysis
- Multiple regression
- Multivariate statistical analysis
- Principal Component Analysis, PCA

EXPERIMENT DESIGN AND OPTIMISATION
- Randomness and error prediction
- ANOVA two-way analysis of variance
- Experiment optimisation

ADDITIONAL APPLICATIONS OF EMBEDDING

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face lectures in the classroom and computer-based laboratory exercises
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory*	Support of the learning process through MS TEAMS that supports the submission of laboratory reports and student assignments, the posting of lectures and additional teaching material, and the posting of announcements and grades.

education, communication with students	

TEACHING METHODS

The manner and methods of teaching are described in detail.

Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS

Activity	*Semester workload*
Lectures (14 presentations of 4 hours)	56
Laboratory exercises (laboratory time for 14 exercises)	42
Student presentations (preparation and presentation time)	36
2 X Written exams (χρόνος εξέτασης και μελέτης)	60
Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Course duration in weeks= 14)	56
Total hrs	250
ECTS (25 hrs / ECTS)	**10**

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student evaluation in ENGLISH

Type of Evaluation	**Points per evaluation**
Lab exercises	14 lab exercises x 2 points per exercise = 28 points
Student presentation	1 presentation x 22 points per presentation = 22 points
Intermediate Progress Exam	15 points
Final Exam	15 points
	Total = 100 points

Students will be given a sample lab exercise that they can follow for their own exercises.
The intermediate and finals exam will contain multiple choice questions covering the material covered in the lecture topics. In the topics requiring calculations, the relevant equations will be given.
For their presentations, an indicative bibliography from peer-reviewed international journals will be provided and students will choose an article related to analytical chemistry.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- Miller J.N. and Miller J.C., Statistics and Chemometrics for Analytical Chemistry, Pearson Education Limited, 2000.
- Ν. Χανιωτάκης, Μ. Φουσκάκη, Κ. Περδικάκη, Β. Βαμβακάκη, Μ. Χατζημαρινάκη (2009). Ποσοτική Χημική Ανάλυση (Μετάφραση D. C. Harris). Quantitative Chemical Analysis. Πανεπιστημιακές Εκδόσεις Κρήτης, Ηράκλειο.

- T.P. Hadjiioannou, G.D. Christian, M.A. Koupparis, P.E. Macheras (1993). Quantitative Calculations in Pharmaceutical Practice and Research. VCH, New York.
- G. D. Christian (1994). Analytical Chemistry. J. Wiley and Sons, New York.
- D. C. Harris (2007). Quantitative Chemical Analysis. W. H. Freeman, New York.

- Related academic journals:

- Analytical Chemistry (ACS)
- Journal of Chromatography B
- Science of the Total Environment

EMP56- ENZYMATIC AND MICROBIAL TECHNOLOGY IN ENVIRONMENTAL APPLICATIONS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**EMP56**	**SEMESTER**	**WINTER**
COURSE TITLE	ENZYMATIC AND MICROBIAL TECHNOLOGY IN ENVIRONMENTAL APPLICATIONS		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
	Lectures and exercises	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Special background		
PREREQUISITE COURSES:	No prerequisite courses are required. Basic knowledge of Biochemistry and Organic Chemistry is desirable. Students should not have taken the undergraduate course "CHEM-060 Enzyme Biotechnology" of the Department of Chemistry, due to partial overlap of material		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and/or English		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	yes		
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST112/		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

Enzyme Technology is by default a multidisciplinary field that brings together Organic Chemistry, Biochemistry, Microbiology, Genetics, Molecular Biology, Chemical Engineering, Bioinformatics, Physics and other sciences.
The main purpose of the course is to educate students on enzymology and on methodology in current biotechnology, in order to be able to respond to key issues such as environmental protection and to develop new industrial (bio)processes, in line with the principles of green chemistry.
The expected learning outcomes and abilities that students will develop are as follows:

- Deepening the biochemical, microbiological and genetic fundamental understanding of biotechnological applications.
- Basic understanding of metabolic engineering and mechanical processes
- Introducing basic biotechnological methods
- Understanding the width of current biotechnological methods
- Autonomous preparation of a review for a topic.
- Critical thinking on the development of bioremediation approaches

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

Through the seminars, graduates develop generic skills that will be useful in research and professional environments, so that they can meet the current challenges of the field. In particular, some of the generic competences cultivated in the context of this course are:
- Search, analysis and synthesis of data and information, including the use of the necessary technologies
- Analysis, analysis, data analysis, analysis and analysis of data and information using the tools and techniques available, including the use of analytical and analytical techniques.
- Generation of new research ideas
- New ways of working with new ideas and new approaches
- Exercising criticism and self-criticism
- Promotion of free, creative and deductive thinking

(3) SYLLABUS

Lectures:
- Introduction to enzymology
- Introduction to Enzyme Enzymology: Introduction to Enzyme Enzymology.
- Enzyme kinetics

- Catalytic mechanisms
- Enzyme activity regulation
- Biocatalyst immobilisation
- Types of bioreactors and bioprocesses
- Biocatalysis in unconventional systems
- Downstream processing
- Biocatalytic strategies - Reaction sequences
- Biocatalytic applications
- Environmental biotechnology
- Green biotechnology
- Analytical biotechnology

Seminars:
- Introduction to molecular biology and biochemistry methods
- Cloning methods
- Methods of genetic modification
- Expression systems
- Cell lysis and sterilization methods
- Purification and downstream processing methods
- Analytical methods for the detection of enzyme activity
- Methods for structure determination

Semester project:
- Development and support of a bioremediation process

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face. Could be partially done by synchronous distant learning
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	The seminars are organised as roundtable discussions, where students work in groups of two, and the discussions after the presentations involve all groups to determine the best solution to the problems given. Students are also trained in the use of communication tools, such as presentation software, through the support of their assignments. Various bioinformatics analysis tools are discussed in the lectures, and used in the seminars.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	***Semester workload***
Lectures	39
Seminar presentations	26
Semester work	85
Study and critical analysis of literature	85
Presentation of semester work	15
Total	***250***
Course total	

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Evaluation language: Greek or English Assessment method: 50 % written examination (multiple choice, short development, etc.) in the course lectures 30 % peer-review of seminar presentations 20 % peer-review assessment of the written work and presentation of the semester-long topic assigned to the group.

(5) ATTACHED BIBLIOGRAPHY

- *Suggested bibliography:*

- "Enzyme Biocatalysis: Principles and applications" A. Illanés. 2008, Springer Science. ISBN: 978-1-4020-8360-0
- "Biocatalysts & Enzyme Technology" K. Buchholz / V. Kasche / U.T. Bornscheuer. 2012, Wiley-VCH. ISBN: 978-3-527-32989-2
- "Biotechnology for Beginners" – R. Renneberg, 2016 (2nd edition), Elsevier. ISBN:978-0-12-801224-6
- Διαλέξεις μαθήματος και άλλο ηλεκτρονικό υλικό που θα διαμοιραστεί στις διαλέξεις.

- *Related academic journals:*

ChemBioChem, ChemCatChem, Enzyme And Microbial Biotechnology, Process Biochemistry, Applied Microbiology and biotechnology

EMP58- CLIMATE CHANGE, MITIGATION, ADAPTATION, SUSTAINABLE DEVELOPMENT GOALS

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**EMP58**	**SEMESTER**	**WINTER**
COURSE TITLE	CLIMATE CHANGE, MITIGATION, ADAPTATION, SUSTAINABLE DEVELOPMENT GOALS		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge, skills development
PREREQUISITE COURSES:	Environmental Chemistry and Physics – Climate Change
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and English depending on the trainees
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES in English
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The aim of the course is to present

- the changes in the climate of our planet due to both natural causes and human influence,
- the multifaceted effects of climate change,
- the objectives of sustainable development,
- as well as measures taken to achieve them that are directly related to the environment.

- Students will acquire knowledge of legislation relevant to the protection and management of the environment and the mitigation of climate change.
- Students should acquire the ability to present a summary of a scientific article related to climate change, mitigation, adaptation and sustainable development in an interesting and scientifically correct way.
- Students should be able to present a summary of a climate change and SDG related scientific article in an interesting and scientifically sound manner.
- Student will also learn to work as a team.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology *Adapting to new situations* *Decision-making* *Working independently* *Team work* *Working in an international environment* *Working in an interdisciplinary environment* *Production of new research ideas*	*Project planning and management* *Respect for difference and multiculturalism* *Respect for the natural environment* *Showing social, professional and ethical responsibility and sensitivity to gender issues* *Criticism and self-criticism* *Production of free, creative and inductive thinking* *……* *Others…* *……*

- Search for, analysis and synthesis of data, environmental laws, and information, with the use of the necessary technology
- Working independently
- Team work
- Working in an interdisciplinary environment
- Decision -making
- Project planning and management
- Respect for the natural environment
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

Students will be introduced to

Climate change and its impacts on the environment, ecosystems, humans and the economy.
Feedback mechanisms and related challenges to address climate change.
Historical data and predictions of numerical models for the future.
Scenarios of technological, economic and social evolution of humanity.
Projections of air pollutant emissions.
Analysis of the United Nations Sustainable Development Goals (SDGs).
Legislation to limit environmental pollution.
Water Framework Directive
Circular economy
National Energy and Climate Plan
Trade in air pollutants
International negotiations (Kyoto Protocol, Paris Agreement, etc.)
Climate change mitigation options
Ways of adapting to climate change in different sectors of activity
European and national strategies for adaptation to climate change.

Group and individual work

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	All lectures will be given in the classroom and activities will be conducted face-to-face. Remote teaching will only be resorted to in exceptional cases.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational*	

Activity	*Semester workload*
Lectures (10 lectures 4 hrs)	40
Assignments (4 assignment literature research)	56

visits, project, essay writing, artistic creativity, etc. *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	Student Presentations (preparation and presentation time)	58
	written Exam (exam time + study time = 40 h)	40
	Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Study duration in weeks =14)	56
	Total hrs	250
	ECTS (25 hrs / ECTS)	10
	Course total ECTS	***10***

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	**Student evaluation in GREEK or ENGLISH** **Type of Evaluation** — **Points per evaluation** **Home assignments** — 4 home assignments x 5 points per assignment = 20 points **Student presentation** — 1 presentation = 30 points **Written Exam** — 1 x 50 points = 50 points Total = 100 points Students will be instructed on how to perform literature research and their assigned work as well as how to best make their presentations. Assignments: will include an in-depth study of a case study for SDG application which will then be discussed in the group. Presentations: Students will choose a recent research topic that is relevant to the course from the international literature, i.e. a research paper published in the last 5 years, and present it in a brief 20-minute presentation. Grading: Rubrics will be provided for each graded assignment. Final Exam: The final exam will contain multiple-choice questions that will cover the topics of the lectures and the discussed assignments, as well as a number of topics to develop that will enable the evaluation of the acquired knowledge by the students.

(5) ATTACHED BIBLIOGRAPHY

1. IPCC reports: http://www.ipcc.ch
2. https://csl.noaa.gov/assessments/ozone/2022/ Scientific Assessment of Ozone Depletion. WMO reports, Geneva
3. https://csl.noaa.gov/assessments/ozone/2022/twentyquestions/ Twenty Questions and Answers about the Ozone Layer.
4. https://sdgs.un.org/goals
5. https://ypen.gov.gr/perivallon/poiotita-tis-atmosfairas/nomothesia/
6. https://ypen.gov.gr/perivallon/klimatiki-allagi/prosarmogi-stin-klimatiki-allagi/
   https://ypen.gov.gr/perivallon/ydatikoi-poroi/odigia-plaisio-gia-ta-nera/

SEMESTER B

EMP52- PHYSICOCHEMICAL AND BIOCHEMICAL PROCESSES IN WASTE TREATMENT

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**ΕΜΠ52**	**SEMESTER**	**SUMMER**
COURSE TITLE	Physicochemical and Biochemical Processes in Waste Treatment		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and Lab experiments		4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized background, skills development		
PREREQUISITE COURSES:	Environmental Chemistry, Analytical Chemistry, General Chemistry		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and English, depending on the students' fluency		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes		
COURSE WEBSITE (URL)			

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- The aim of the course is to acquire basic knowledge in the fields of waste and industrial water treatment and management.
- The aim is to familiarise students with the basic physico-chemical processes applied in waste management, as well as with laboratory methods for the determination of the main environmental parameters in water and waste.
- Students should acquire the ability to critically search and refer to scientific literature.
- Students will also learn to work in teams.
- Students should acquire the ability to present a summary of an environmental chemistry related scientific article in an interesting and scientifically sound manner.
- Students will learn how to correlate various physicochemical and biochemical processes with their impact on the environment.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Team work
- Working in an interdisciplinary environment
- Decision -making
- Project planning and management
- Respect for the natural environment
- Criticism and self-criticism
- Production of free, creative, and inductive thinking

(3) SYLLABUS

Content of lectures and laboratory exercises

Module 1
Wastewater treatment technologies
Sources and flows of wastewater & treatment stages
Characteristics of wastewater
Preliminary & primary treatment
Secondary treatment: activated sludge systems - prolonged aeration
Tertiary treatment: Nitrogen & phosphorus removal, wastewater refining
Disinfection
Treatment of excess sludge
Reuse of treated wastewater for irrigation

Module 2
Metallic corrosion and its control in industrial waters.
Formation of insoluble salts in industrial waters and their prevention.
Development of micro-organisms and biofilms in industrial waters and their management.

Module 3
Introduction to the concepts of solid waste management
Aerobic treatment
Anaerobic treatment
Energy recovery
Processes for the production of high added value products

The course will include **laboratory exercises** such as the following:

- Solids measurement.
- Total Solids (volatile - non-volatile) - Suspended Solids (SS), Total Dissolved Solids (T.D.S), Precipitated Solids (Imhoff cone).
- Measurement of physico-chemical water parameters. (temperature, pH, conductivity, total dissolved solids, hardness, determination of Ca^{+2}, Mg^{+2}, Na^{+1}, residual chlorine.
- Ion chromatography. Analysis of basic ions in water (Cl^{-}, SO_4^{-2}, NO_2^{-}, NO_3-, PO_4^{-3}).

- Organic pollution parameters. (Dissolved oxygen, BOD, COD).
- Measurement of total nitrogen (NO_3-N) and total phosphorus (PO_4-P).
- BMP test.
- Processing of results and assignment of written work.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	All lectures will be given in the classroom and experiments will be conducted in the laboratories (all face-to-face). Remote teaching will only be resorted to in exceptional cases.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of laboratory reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	***Semester workload***
Lectures (13 lectures 4 hrs)	52
Laboratories (lab time for lab experiments + preparation of experiments + writing lab reports)	52
Student Assignments αnd presentations (preparation and presentation time)	30
Final Exam (exam time + study time)	38
Self-study (study hrs / lecture hrs x lecture hrs per week = 1,50 x 4 = 6,00 Course duration in weeks =13)	*78*
Total hrs	250
ECTS (25 hrs / ECTS)	10

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student Evaluation

Type of Evaluation	Points per evaluation
Lab Reports	25
Student presentation	15
Final Exam	60
	Total = 100 points

Students will be given a sample lab report that they can follow for their own lab reports.

Students will be also instructed on how to perform literature research and their assigned work as well as how to best make their presentations.

The final examination will contain development questions & multiple choice questions covering the material covered in the lecture topics, as well as design & sizing problems for

	waste treatment plants. The topics requiring calculations will be given the relevant equations. For their presentations, students will select a waste treatment/waste management topic from a scientific article published in an international scientific journal within the last 5 years.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- "Wastewater Engineering: Treatment, Disposal, Reuse", Metcalf & Eddy (revised by G. Tchobanoglous, F. L. Burton, McGraw-Hill, Inc. 1991, 3rd Edition.
- Solid Waste Engineering and Management: Volume 1 by Lawrence K. Wang, Springer Nature Switzerland A&G

-Instructor notes

- Mineral Scales and Deposits: Scientific and Technological Approaches, Amjad, Z.; Demadis, K.D., Editors, Publisher: Elsevier, 2015, ISBN: 9780444632289.
- Water-Formed Deposits: Fundamentals and Mitigation Strategies, Amjad, Z.; Demadis, K.D., Editors, Publisher: Elsevier, 2022, ISBN: 9780128228968.

- Related academic journals:

Selected articles from relevant journals:

Applied Catalysis B: Environmental
Chemical Engineering Journal
Environmental Science and Technology
Catalysis Today
Waste Management
Agricultural Water Management
Industrial & Engineering Chemistry Research (ACS)
Desalination (Elsevier)
International Journal of Corrosion and Scale Inhibition

EMP53- MONITORING AND CONTROLING AIR POLLUTION

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**EMP53**	**SEMESTER**	**SUMMER**
COURSE TITLE	MONITORING AND CONTROLING AIR POLLUTION		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**

Lectures and Laboratory Exercises	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	special background, specialised general knowledge, skills development
PREREQUISITE COURSES:	Analytical Chemistry, Physical Chemistry, Environmental Chemistry, Organic Chemistry
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek or English depending on the students
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES
COURSE WEBSITE (URL)	

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- The aim of the course is to study the systems for collecting, monitoring and limiting air pollution.
- The students will be familiarized with field measurements of gaseous and particulate pollutants in the atmosphere and of meteorological parameters.
- The principle of operation of air pollution control systems is examined.
- The student is also informed about the legislation, the structure and the methodology of preparing an environmental impact study.
- Students should be able to present a scientific article in a short and understandable way on environmental field measurements.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search, analysis and synthesis of data and information, using the necessary technologies
-Working independently

-Team work- Decision-making
- Promotion of free, creative and inductive thinking
- Respect for the natural environment

(3) SYLLABUS

- Introduction to air pollution control.
- Air pollutants and their effects on humans, materials and crops.
- Pollution control legislation and strategies, emission estimation, general principles and basic philosophy for designing emission control systems.
- Particulate pollution - particle dynamics - particle behaviour in the atmosphere - particle distribution functions (mass, size, number)
- Gaseous pollutants - active compounds, greenhouse gases
- Air pollution monitoring systems.
- Automatic sensors of meteorological parameters.
- Sampling and laboratory analysis of atmospheric samples of gases, aerosols, precipitation.
- Automatic aerosol measurements.
- Automatic measurements of air pollutants.
- Remote sensing observation methods.
- Particulate pollution control systems - system performance and penetration; System design and calculations.
- Air pollution control systems from air pollutants - Systems design.
- Application of emission control of pollutants from stationary combustion sources:
  - SO_2 control
  - Control of NOx
- Indoor air pollution.
- Air pollution from mobile sources.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face lectures in the classroom and visits and laboratory experiments at the environmental measurement station of the University of Crete at Finokalia, Lassithi and the air pollution monitoring station in the city of Heraklion.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	Support of the learning process through MS TEAMS that supports the submission of laboratory reports and student assignments, the posting of lectures and additional teaching material, and the posting of announcements and grades. Use of databases from international networks.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	***Semester workload***
Lectures (5 presentations of 4 hours)	20
Laboratory exercises (laboratory time for 5 exercises and report writing)	60
Field exercise (10 visits to air pollution measuring stations	60
Student presentations (preparation and presentation time)	20
Final Exam (exam time + study time)	15

	Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Course duration in weeks =5)	20
	Project (management of a research station, measurement conduction, sample collection and data analysis)	55
	Total hrs	250
	ECTS (25 hrs / ECTS)	10

STUDENT PERFORMANCE EVALUATION

Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student evaluation in ENGLISH

Type of Evaluation	Points per evaluation
Project assignment	1 project x 15 points per project= 15 points
Lab Reports	6 lab reports x 10 points per report = 60 points
Student presentation	1 presentation x 10 points per presentation = 10 points
Final Exam	15 points
	Total = 100 points

Students will be given a sample lab report that they can follow for their own lab reports.
The final exam will contain multiple choice questions covering the material covered in the lecture topics. In the topics requiring calculations, the relevant equations will be given.
For their presentations, an indicative bibliography from peer-reviewed international journals will be provided and students will choose an article related to atmospheric measurements.
The study involves an air pollution monitoring station management activity: conducting measurements, data visualization and analysis, sample collection.

(5) ATTACHED BIBLIOGRAPHY

- *Suggested bibliography:*

«Σημειώσεις Ατμοσφαιρικής Τεχνολογίας»: Α. Μπάη, Δ. Μελά, Δ. Μπαλή, ΑΠΘ, 2011
«Guide to Meteorological Instruments and Methods of Observation»: ISBN 978-92-63-10008-5, World Meteorological Organization, 2008

- *Related academic journals:*

Atmospheric Chemistry and Physics
Atmospheric Environment
Atmospheric research
Science of the Total Environment
Atmosphere
Aerosol Science and Technology
Atmospheric Measurement Techniques
Journal of Geophysical Research
Geophysical Research Letters

EMP55- USE OF NUMERICAL MODELS TO SIMULATE ATMOSPHERIC PROCESSES AND PROCESSING OF SATELLITE DATA

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	**EMP55**	**SEMESTER**	**SUMMER**
COURSE TITLE	USE OF NUMERICAL MODELS TO SIMULATE ATMOSPHERIC PROCESSES AND PROCESSING OF SATELLITE DATA		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and hands-on exercises	4	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized general knowledge, special background, skills development
PREREQUISITE COURSES:	Basic knowledge of environmental chemistry Basic knowledge of computer programming
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and English depending on the trainees
IS THE COURSE OFFERED TO ERASMUS STUDENTS	YES in English
COURSE WEBSITE (URL)	https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST111/

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The aim of the course is to introduce students to the numerical simulations of pollutant emissions and the chemical composition of the atmosphere, as well as the processing of environmental data bases with an emphasis on satellite and meteorological data for their categorization and the extraction of correlations.

They are presented briefly

1. Problems in the calculations due to the complexity and non-linearity of the chemistry and physics in the environment and how they are solved.
2. Databases of Air Pollutant Emissions used in Air Quality Models and climate models, Types of emissions and what they depend on (parameterizations), how to create emission databases, examples, hands-on in creating and using emission data and using modern Dispersion Models and Chemistry with online exercises
3. Databases from satellite observations of atmospheric composition and from numerical simulations of climate parameters and how to process them with examples and hands-on exercises.

- For an in-depth understanding of the usefulness of numerical simulations, the student is invited to experiment with the computer, creating his own programs in the fortran programming language and linux operating environment to understand selected environmental processes.
- To process model results and databases, the student is invited to experiment with the computer, creating his/her own programs in python programming language (worksheets with jupyter notebooks) to familiarize him/herself with environmental data management, their visualization and extracting correlations between them.
- Students should acquire the ability to critically search and consult the literature and the Internet to find appropriate databases for the study at hand.
- Students should acquire the ability to organize their thinking, analyze problems in individual questions and compose actions for the success of the final goal. Thus students will learn to create algorithms both for numerical simulations of atmospheric processes and for data processing.
- Students will also learn to work as a team.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*
	…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Team work
- Working in an interdisciplinary environment
- Decision -making
- Project planning and management
- Respect for the natural environment
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(3) SYLLABUS

Module I

Presentation of examples of numerical simulations of pollutant emissions and the chemical composition of the atmosphere, databases including satellite and meteorological data and their usefulness.

A summary of

1) problems in calculations due to the complexity and non-linearity of chemistry and physics in the environment and how they are solved, examples

2) Air Pollutant Emission Databases used in Air Quality Models and Climate Models, Types of emissions and what they depend on (parameterizations), how to create emission databases, examples

3) Databases from satellite observations of atmospheric composition, meteorological data, and from numerical simulations of climate parameters and how to process them with examples.

Module II

Hands-on for the generation and use of emission data and use of modern Dispersion and Chemistry Models with online exercises

- For an in-depth understanding of the usefulness of numerical simulations, the student is invited to experiment with the computer by creating his/her own programs in fortran programming language and linux operating environment to understand selected environmental processes.
- 5 exercises with program development in fortran (emissions of compounds from the sea, calculation of thermal, trimolecular and photolytic reaction constants and lifetime under various atmospheric conditions of temperature pressure and sunshine, diurnal variation of tropospheric ozone, formation of suspended particles in the atmosphere, effect of temperature and sunshine on gas emissions from vegetation)

Module III

Hands-on exercises on Processing of environmental databases with emphasis on satellite and meteorological data for their categorization and extraction of correlations.

- To process model results and databases, the student is invited to experiment with the computer, creating his/her own programs in python programming language (worksheets with jupyter notebooks) to familiarize himself/herself with the management of environmental data, their visualization and the extraction of correlations between them.
- 5 exercises with program development in python (data reading, calculation of averages, daily, monthly, seasonal, longitudinal trends, identification of outliers, statistical comparison and correlations of data series, graphs, data maps, data interpolation to change geographical or temporal resolution, creation of histograms). Use of meteorological data from ERA5 and satellite data from TROPOMI.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	All lectures will be given in the classroom and activities will be conducted face-to-face. Remote teaching will only be resorted to in exceptional cases.
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS*	

Activity	***Semester workload***
Lectures (10 lectures 4 hrs)	40
Hands-on exercises (10 x 8 h/ exercise)	80
Individual work (computer program, problem analysis, algorithm creation, program creation, reporting)	60
written Exam (exam time + study time)	30
Self-study (study hrs / lecture hrs x lecture hrs = 1,00 x 40 = 40,00 Study duration in weeks =14)	40
Total hrs	250
ECTS (25 hrs / ECTS)	10
Course total ECTS	***10***

STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure*	**Student evaluation in GREEK or ENGLISH**

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	**Type of Evaluation** / **Points per evaluation** **Hands-on exercises** — 10 exercices x 2 points per exercice = 20 points **Individual work** — 60 points **Written Exam** — 20 points Total = 100 points Students will be given an algorithm to understand the distribution of grades and the criteria by which their reports will be graded. The final examination will contain multiple choice questions covering the material covered in the lecture topics. For the individual assignment students will be required to study a topic related to the Environment by creating a fortran or python program. They will do problem analysis, algorithm creation, program creation, and finally report. The assignment requires delivery of the program and report with results.

(5) ATTACHED BIBLIOGRAPHY

27. Lecture notes available on eclass
28. Jacobson M.Z., Fundamentals of Atmospheric Modeling, Cambridge Univ. Press, 1999.
29. Kanakidou, M., 1996. Tropospheric Chemistry Models, in ERCA book Volume 2, C. F. Bourton (eds.), Les éditions de physique, Les Ulis, France, 245-264
30. Brasseur G. P. and Jacob D.J., Modeling of Atmospheric Chemistry, Cambridge University Press, pp. 606, 2017.
31. https://www.python.org/
32. https://fortran-lang.org/
33. ΑΒΟΥΡΗΣ, Ν., ΚΟΥΚΙΑΣ, Μ., ΠΑΛΙΟΥΡΑΣ, Β., ΣΓΑΡΜΠΑΣ, Κ., PYTHON – ΕΙΣΑΓΩΓΗ ΣΤΟΥΣ ΥΠΟΛΟΓΙΣΤΕΣ – Πανεπιστημιακές Εκδόσεις Κρήτης, 2023

EMP57- ADVANCED TOPICS IN MASS SPECTROMETRY

(1) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE	ΕΜΠ57	**SEMESTER**	SPRING
COURSE TITLE	ADVANCED TOPICS IN MASS SPECTROMETRY		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
Lectures and Lab experiments		5	10
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized background, skills development		
PREREQUISITE COURSES:	Undergraduate Analytical Chemistry courses: On Qualitative and Quantitative Analysis, Instrumental Analysis)		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes		
COURSE WEBSITE (URL)	eClass website: https://www.chemistry.uoc.gr/eclass/courses/CHEM-POST104/		

(2) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

- Students should fully understand and be able to explain the operating principles of all advanced mass spectrometry techniques and associated separation methods. They should be able to explain the advantages and disadvantages of each technique, as well as be able to present applications of the techniques.
- Students should be able to recommend appropriate mass spectrometry techniques for each group of analytes and the different types of samples (sample matrices).
- Students should understand the logic of the sample preparation steps that precede instrumental analyses, and have the skill to select appropriate processing steps depending on the type of sample they need to analyse.
- Through laboratory experiments students will acquire the skills and knowledge on the correct and efficient operation of selected mass spectrometers (atomic and molecular mass) for advanced analyses.
- Students will acquire knowledge on the correct processing of data recorded with each technique and for each type of sample and analyte.
- Students should acquire the ability to present a summary of an analytical chemistry-related

scientific article in an interesting and scientifically sound manner.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Adapting to new situations
Decision-making
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas
Project planning and management
Respect for difference and multiculturalism
Respect for the natural environment
Showing social, professional and ethical responsibility and sensitivity to gender issues
Criticism and self-criticism
Production of free, creative and inductive thinking
……
Others…
…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Decision-making
- Project planning and management
- Exercise criticism and self-criticism
- Promotion of free, creative and inductive thinking

(3) SYLLABUS

Wk #	Activity Title	Activity Type	Student Assignments
1	Advanced inductively coupled plasma mass spectrometry (ICP-MS)	Lecture + Lab tour	Home exercise
2	Water Analysis using ICP-MS	Lab experiment	Lab Report
3	Single-Particle ICP-MS for the determination of metal-containing nanoparticles	Lecture	
4	Determination of Ag and Au nanoparticles	Lab experiment	Lab Report
5	Multi Collector (MC) ICP-MS for accurate isotope ratio determination in geological, environmental, and archaeological samples	Lecture	
6	Advanced Topics in Mass Spectrometry - Instrumentation	Lecture + Lab tour	
7	Accurate Mass MS for determining the chemical formulas of unknowns	Lecture + Lab	Lab Report
8	Proteomics using MS – Part 1 (peptide mapping, top-down proteomics)	Lecture	
9	Proteomics using MS – Part 2 (database search for protein identification)	Lecture	Home exercise
10	Peptide sequencing	Lecture + Lab	Lab Report
11	Real-Time Air Quality Monitoring Using Direct MS (SIFT-MS-based environmental applications)	Lecture	
12	Physical chemistry experiments using Mass Spectrometry: Determination of the gas-phase basicity of amino acids	Lecture + Lab	Lab Report
13	LC – MS/MS for quantitative analysis: Quantitation of caffeine and benzoic acid in beverages and energy drinks	Lecture + Lab	Lab Report
14	Student Presentations (topics to be assigned during weeks 3-6)		Student Presentation

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY
Face-to-face, Distance learning, etc.

All lectures will be given in the classroom and experiments will be conducted in the mass spectrometry instrument laboratories (all face-to-face). Remote teaching will only be resorted to in exceptional cases (e.g. illness).

USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students

The electronic platform eClass will be used to support all teaching activities. This electronic platform supports the submission of laboratory reports and student assignments, the posting of lectures and additional teaching materials, and the posting of announcements and grades with immediate and automatic notification of students via their e-mail.
Use of databases and special software to interpret the results of mass spectrometry experiments.

TEACHING METHODS
The manner and methods of teaching are described in detail.
Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS

Activity	*Semester workload*
Lectures (14 lectures 4 hrs)	56
Laboratories (lab time for 6 lab experiments + writing lab reports)	66
Assignments (2 home assignments)	18
Student Presentations (preparation and presentation time)	17
Final Exam (exam time + study time)	37
Self-study (study hrs / lecture hrs x lecture hrs per week = 1,00 x 4 = 4,00 Course duration in weeks =14)	56
Total hrs	250
ECTS (25 hrs / ECTS)	10

STUDENT PERFORMANCE EVALUATION
Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem-solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other

Specifically-defined evaluation criteria are given, and if and where they are accessible to students.

Student evaluation in ENGLISH

Type of Evaluation	**Points per evaluation**
Home assignments	2 home assignments x 5 points per assignment = 10 points
Lab Reports	6 lab reports x 10 points per report = 60 points
Student presentation	1 presentation = 15 points
Final Exam	15 points
	Total = 100 points

Lab reports: Students are given a lab report template for writing their lab reports.

Assignments: Home assignments will include numerical calculations, questions based on lecture materials, and other types of assignments in which student creativity is emphasized.

Presentations: Students will choose a recent research topic from the analytical chemistry literature, i.e. a research paper published in the last 5 years, and present it in a brief 15-minute presentation.

	Grading: Rubrics will be provided for each graded assignment. Final Exam: The final exam will contain 15 multiple-choice questions on the physical-chemical principles of operation of the analytical techniques covered, as well as the advantages and disadvantages of each technique for a specific type of analysis.

(5) ATTACHED BIBLIOGRAPHY

- Suggested bibliography:

- **Quantitative Chemical Analysis, Daniel C . Harris , Charles A . Lucy , 10th Ed, W.H. Freeman & Company**
- **Instructor Notes: Advanced Mass Spectrometry Experiments for Chemistry Students, S.A. Pergantis, Univ. of Crete**
- Mass Spectrometry for Chemists and Biochemists, Robert A. W. Johnstone and Malcolm E. Rose, Cambridge University Press.

- Related academic journals:

- ***Journal of Chemical Education (ACS)***
- ***Analytical Chemistry (ACS)***
- *Reviews in Mass Spectrometry*
- *The Analyst*
- *Analytica Chimica Acta*
- *Journal of the American Society for Mass Spectrometry*
- *Journal of Chromatography B*
- *Talanta*

DIPLOMA THESIS OUTLINE IN ENGLISH

(6) GENERAL

SCHOOL	SCHOOL OF SCIENCES & ENGINEERING		
ACADEMIC UNIT	CHEMISTRY		
LEVEL OF STUDIES	GRADUATE		
COURSE CODE		**SEMESTER**	**SUMMER**
COURSE TITLE	Diploma thesis		
INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*		**WEEKLY TEACHING HOURS**	**CREDITS**
Literature research, research work, processing of results, writing and defence of the thesis		58	30
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).			
COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialized knowledge, skills development		
PREREQUISITE COURSES:	1st year lectures for 60 ECTS		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek and/or English		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	NO		
COURSE WEBSITE (URL)			

(7) LEARNING OUTCOMES

Learning outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The aim of the thesis is to introduce the MSc student in scientific research on a topic related to the Master Program, to develop their research skills for the preparation of high-level research projects, preparing the MSc student both for independent work in the public and private sectors and for doctoral studies. The MSc student will acquire the necessary skills for independent research and use of sources and bibliography to write research studies as well as the ability to defend their scientific opinions in a substantiated manner.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology
Adapting to new situations
Decision-making
Working independently
Team work
Working in an international environment
Working in an interdisciplinary environment
Production of new research ideas
Project planning and management
Respect for difference and multiculturalism
Respect for the natural environment
Showing social, professional and ethical responsibility and sensitivity to gender issues
Criticism and self-criticism
Production of free, creative and inductive thinking
……
Others…
…….

- Search for, analysis and synthesis of data and information, with the use of the necessary technology
- Working independently
- Team work
- Working in an interdisciplinary environment
- Decision -making
- Project planning and management
- Respect for the natural environment
- Criticism and self-criticism
- Production of free, creative and inductive thinking

(8) SYLLABUS

The Diploma Thesis is prepared within a period of one semester but the preparatory work with the selection of the subject may have begun earlier.
It includes bibliographic research, identification of scientific questions to be investigated, laboratory research, processing of research results, writing and presenting them.
For its preparation, the graduate student undertakes, in consultation with the Study Program Committee and a (supervising) lecturer, the preparation of a research project under the guidance and supervision of the academic.
The student and the supervisor jointly determine the schedule of their meetings and the periodic progress review within the timeframe for the completion of the Thesis.
The Study Program Committee and the supervisor are responsible for monitoring and controlling the course of the student's studies.
Regular communication with the supervising academic provides the opportunity for the student to resolve problems, to correct if necessary the research and methodological approach and at the same time to improve the skills of dialectical speech and writing of research papers.
The Diploma thesis is publicly defended before a 3-member examination committee.

(9) TEACHING and LEARNING METHODS - EVALUATION

<table>
<tr><td>DELIVERY
Face-to-face, Distance learning, etc.</td><td>The education is delivered through laboratory work by the student. The student is also attending seminars, systematic discussions and presentation of progress.</td></tr>
<tr><td>USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY
Use of ICT in teaching, laboratory education, communication with students</td><td>Support of bibliographic research through the library's electronic access, use of numerical tools from data interpretation and automatic notification of students via e-mail.</td></tr>
<tr><td>TEACHING METHODS
The manner and methods of teaching are described in detail.
Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.

The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</td><td>
<table>
<tr><th>Activity</th><th>Semester workload</th></tr>
<tr><td>Literature research</td><td>50</td></tr>
<tr><td>Research</td><td>250</td></tr>
<tr><td>Interpretation of the results</td><td>150</td></tr>
<tr><td>Writing of the thesis</td><td>100</td></tr>
<tr><td>Presentation and defence</td><td>200</td></tr>
<tr><td>Total hrs</td><td>750</td></tr>
<tr><td>ECTS (25 hrs / ECTS)</td><td>30</td></tr>
<tr><td></td><td></td></tr>
<tr><td>Course total ECTS</td><td>30</td></tr>
</table>
</td></tr>
<tr><td>STUDENT PERFORMANCE EVALUATION
Description of the evaluation procedure

Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination,</td><td>Student evaluation in GREEK or ENGLISH
Support for bibliographic research through the library's electronic access, and automatic notification of students via e-mail. Three-member Examination Committee, in which the supervisor and two (2) other members participate, who hold a doctoral degree, and belong to the categories of teachers as defined in article 83 of Law 4957 (Government Gazette A'</td></tr>
</table>

public presentation, laboratory work, clinical examination of patient, art interpretation, other *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	141/21.07.2022). The members of this Committee must have the same or related scientific expertise as the subject of the program. The examination of student by the Three-member Examining Committee takes place after the public presentation of the work and the questions of the committee or in the case of an obstruction of a member of the committee, on another day and time. The three-member examining committee decides after the examination on the awarding of the M.D. through a written report. The Thesis is graded Excellent, Very Good and Good.

(10) ATTACHED BIBLIOGRAPHY

The bibliography varies depending on the topic of the thesis. Some bibliographic works are given by the supervisor and M.F. motivated to explore the literature independently.