## COURSE OUTLINE

## (1) GENERAL

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| **SCHOOL** | SCHOOL OF SCIENCES | | |
| **DEPARTMENT** | DEPARTMENT OF CHEMISTRY | | |
| **LEVEL OF STUDIES** | ISCED level 6 – Bachelor's or equivalent level | | |
| **COURSE CODE** | YN604 | **SEMESTER** | 6th Semester |
| **COURSE TITLE** | Instrumental Analysis | | |

| **TEACHING ACTIVITIES**<br>*If the ECTS Credits are distributed in distinct parts of the course e.g. lectures, labs etc. If the ECTS Credits are awarded to the whole course, then please indicate the teaching hours per week and the corresponding ECTS Credits.* | **TEACHING HOURS PER WEEK** | **ECTS CREDITS** |
|---|---|---|
| Theory | 4 | 7 |
| Lab | 3 | |
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| *Please, add lines if necessary. Teaching methods and organization of the course are described in section 4.* | | |

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| **COURSE TYPE**<br>*Background, General Knowledge, Scientific Area, Skill Development* | • General Knowledge<br>• Skills Development |
| **PREREQUISITES:** | No |
| **TEACHING & EXAMINATION LANGUAGE:** | Greek |
| **COURSE OFFERED TO ERASMUS STUDENTS:** | No |
| **COURSE URL:** | |

## (2) LEARNING OUTCOMES

**Learning Outcomes**
*Please describe the learning outcomes of the course: Knowledge, skills and abilities acquired after the successful completion of the course.*

**Upon successful completion of the course, the student is expected to:**

- Understand the fundamental principles, instrumentation, and classification of modern instrumental analytical techniques.
- Explain the theory and operation of spectroscopic methods, including UV–Vis, IR, molecular luminescence, atomic absorption/emission, and mass spectrometry (MS and ICP-MS).
- Describe the principles of chromatographic separation techniques (LC and GC) and their coupling with spectrometric detectors (hyphenated techniques).
- Comprehend the concepts of calibration, analytical signals, and noise, and apply quantitative methods for data interpretation.
- Recognize the applications, advantages, and limitations of different analytical techniques in chemical, environmental, and food analysis.

**Knowledge**

- Knowledge and understanding of the quality characteristics of Instrumental Analytical Techniques
- Knowledge and understanding of various quantification techniques in quantitative chemical analysis
- Knowledge of the theory and operation of the instrumental analytical techniques taught

- Knowledge of the field of application of instrumental analytical techniques
- Knowledge and understanding of the theory and analytical applications of instrumental techniques

**Skills**

- Perform instrumental analyses safely and efficiently in a laboratory environment
- Apply suitable sample preparation techniques and select the most appropriate instrumental method for a given analytical problem
- Record, process, and interpret analytical data, construct calibration curves, and calculate measurement uncertainties and errors
- Operate fundamental analytical instruments (pH-meter, conductometer, polarimeter, UV–Vis spectrophotometer, flame photometer, HPLC, GC)
- Evaluate the performance characteristics of analytical methods (accuracy, precision, sensitivity, linearity, detection limits)
- Implement basic method optimization and validation procedures

**Competences**

- Ability to design analytical methodologies for the determination of chemical elements and compounds
- Ability to perform analytical determinations from the sampling stage to the presentation of results
- Teamwork and scientific communication skills through preparation of laboratory reports and presentations.
- A responsible attitude toward laboratory safety and environmental sustainability in analytical practice.

**General Skills**

*Name the desirable general skills upon successful completion of the module*

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| *Search, analysis and synthesis of data and information,* | *Project design and management* |
| *ICT Use* | *Equity and Inclusion* |
| *Adaptation to new situations* | *Respect for the natural environment* |
| *Decision making* | *Sustainability* |
| *Autonomous work* | *Demonstration of social, professional and moral responsibility and* |
| *Teamwork* | *sensitivity to gender issues* |
| *Working in an international environment* | *Critical thinking* |
| *Working in an interdisciplinary environment* | *Promoting free, creative and inductive reasoning* |
| *Production of new research ideas* | |

Through the lectures and laboratory exercises, students are expected to acquire the following general competences:

- Search, analysis, and synthesis of new concepts and information
- Ability to transform theory into practice
- Ability to apply knowledge to solve problems in analytical chemistry
- Presentation, and evaluation of experimental results; quality assurance, etc.
- Capacity for independent work during the collection and processing of analytical parameters
- Ability to collaborate effectively within a team to achieve educational goals
- Decision-making ability
- Ability to exercise critical thinking and self-evaluation
- Ability to work in an interdisciplinary environment
- Acquisition of theoretical and practical knowledge necessary for the further education of students at higher levels of studies

## (3) COURSE CONTENT

**Theoretical part**

Week 1: - Introduction to Instrumental Analytical Techniques
- Classification of Instrumental Analysis Methods

Week 2: - Quantification Techniques in Instrumental Analysis- Calibration
- Signal and Noise, Performance characteristics of analytical methods

Week 3: - Introduction to spectrophotometric techniques
- Components of Optical Instruments

Week 4: - Beer-Lambert law, Ultraviolet/Visible Spectrophotometry (UV-Vis)

Week 5: - Infrared Spectrophotometry (IR)
- Molecular Luminescence Spectrometry

Week 6: Introduction to Atomic Spectroscopy

Week 7: - Atomic Absorption Spectrometry
- Atomic Emission Spectrometry

Week 8: Atomic Mass Spectrometry

Week 9: Mass Spectrometry (MS): Principles, applications and hyphenated techniques

Week 10: Inductively Coupled Plasma Mass Spectrometry (ICP-MS)

Week 11: Separation Techniques in Instrumental Analysis – Introduction

Week 12: Liquid Chromatography (LC)

Week 13: Gas Chromatography (GC)

**Laboratory part**

Week 1: Functionality of the Instrumental Analysis Laboratory – Organization and recording of measurements in the laboratory report, data processing, error calculation, and preparation of the laboratory report.

Week 2: pH-metry – Titration of a weak acid with a strong base, construction of the titration curve, determination of the equivalence point, acid concentration, dissociation constant (Ka), degree of dissociation, and pH.

Week 3: Conductometry – Determination of the dissociation constant (Ka) and the degree of dissociation of a weak electrolyte, construction of a conductometric neutralization curve, and determination of solution concentration.

Week 4: Polarimetry – Determination of the specific rotation of an optically active substance and calculation of the inversion constant of sucrose.

Week 5: Flame Photometry – Determination of K, Na, and Ca in water samples.

Week 6: UV/Visible Spectroscopy (UV-Vis) 1– Absorption spectrum of $Mn^{2+}$ ions, construction of a calibration curve, and measurement of $Mn^{2+}$ solutions of unknown concentration.

Week 7: UV Spectroscopy 2– Simultaneous spectrophotometric determination of binary mixtures: Mn (as $MnO_4^-$) and Cr (as $Cr_2O_7^{2-}$) in solution.

Week 8: UV Spectroscopy 3– Spectrophotometric determination of the API in commercial aspirin tablets

Week 9: High-Performance Liquid Chromatography (HPLC) – Determination of organic compounds, optimization of analytical methods, qualitative and quantitative analysis of a mixture (simulated system).

Week 10: Gas Chromatography (GC) – Determination of organic compounds, chromatographic parameters, qualitative analysis

Week 11: Gas Chromatography (GC) –Separation of mixture components, and quantitative determination using standard compounds.

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| Week 12: Make-up lab courses<br>Week 13: Final test on all lab exercises |

## (4) LEARNING & TEACHING METHODS - EVALUATION

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| **TEACHING METHOD**<br>*Face to face, Distance learning, etc.* | Face to face |
| **USE OF INFORMATION & COMMUNICATIONS TECHNOLOGY (ICT)**<br>*Use of ICT in Teaching, in Laboratory Education, in Communication with students* | Use of ICT in Teaching<br>Use of ICT in Communication with students |
| **TEACHING ORGANIZATION**<br>*The ways and methods of teaching are described in detail.*<br>*Lectures, Seminars, Laboratory Exercise, Field Exercise, Bibliographic research & analysis, Tutoring, Internship (Placement), Clinical Exercise, Art Workshop, Interactive learning, Study visits, Study / creation, project, creation, project. Etc.*<br><br>*The supervised and unsupervised workload per activity is indicated here, so that total workload per semester complies to ECTS standards.* | <table><tr><th>Activity</th><th>Workload/semester</th></tr><tr><td>Lectures</td><td>52</td></tr><tr><td>Lab</td><td>39</td></tr><tr><td>Bibliographic research & analysis</td><td>56</td></tr><tr><td>Preparation for the final exams</td><td>25</td></tr><tr><td>Final Exam</td><td>3</td></tr><tr><td>Total</td><td>175</td></tr></table> |
| **STUDENT EVALUATION**<br>*Description of the evaluation process*<br><br>*Assessment Language, Assessment Methods, Formative or Concluding, Multiple Choice Test, Short Answer Questions, Essay Development Questions, Problem Solving, Written Assignment, Essay / Report, Oral Exam, Presentation in audience, Laboratory Report, Clinical examination of a patient, Artistic interpretation, Other/Others*<br><br>*Please indicate all relevant information about the course assessment and how students are informed* | **Student evaluation languages**<br>Greek<br>**Method (Formative or Concluding)**<br>Summative<br>**Student evaluation methods**<br>• Multiple-choice questions<br>• True/False questions with clear justification<br>• Short-answer questions<br>• Critical thinking questions<br>• Problem-solving exercises<br>• Laboratory and experimental performance (applicable only to the Laboratory component)<br>• The Laboratory grade contributes **30%** to the final overall course grade (final test in the lab exercises once they are completed)<br>**Rate**<br>**100** |

## (5) SUGGESTED BIBLIOGRAPHY

**Eudoxus**

- Principles of Instrumental Analysis, Skoog, Holler, Crouch, Kostarakis Publications, ISBN: 9786185295066, Book Code in Eudoxus: 102076784
- Analytical Chemistry, Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug, Odysseus Publishing Ltd, ISBN: 978992574674, Book Code in Eudoxus: 86199898
- Analytical Chemistry, Daniel C. Harris, Charles A. Lucy, Broken Hill Publishers, ISBN: 9789925576111, Book Code in Eudoxus: 94644882

Relevant scientific Journals:

- Analytical Chemistry
- Analytica Chimica Acta
- Analytical Bioanalytical Chemistry
- Journal of Electroanalytical Chemistry
- Journal of Chromatography A
- Microchemical Journal
- Talanta
- Microchimica Acta