

SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	Babeş-Bolyai University of Cluj-Napoca
1.2 Faculty	Faculty of Environmental Science and Engineering
1.3 Department	Department of Environmental Analysis and Engineering
1.4 Field of study	Environmental Engineering
1.5 Study cycle	Bachelor
1.6 Study programme / Qualification	Environmental Engineering

2. Information regarding the discipline

2.1 Name of the discipline	Sensors for Environmental Control						
2.2 Course coordinator	Dr. Bocoş-BinţiŃan Victor, Assoc. Prof.						
2.3 Seminar coordinator	Dr. Bocoş-BinţiŃan Victor, Assoc. Prof.						
2.4 Year of study	3	2.5 Semester	6	2.6. Type of evaluation	Ex.	2.7 Regime of the discipline	Optional

3. Total estimated time (in hours per semester of didactic activities)

3.1 Number of hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	2
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28
Time assignment:					hrs.
Learning using manuals, course support, bibliography and course notes					15
Supplementary documentation in the library, using electronic platforms and in the field					15
Preparation of seminars/laboratories, homework themes, reports, portfolios and essays					8
Tutorship					2
Examinations					2
Other activities:					0
3.7 Total individual study hours	42				
3.8 Total hours per semester	98				
3.9 Number of ECTS credits	4				

4. Prerequisites (when necessary)

4.1 Of curriculum:	Promotion of disciplines from the category of chemistry and physics, with emphasis on instrumental analytical chemistry.
4.2 Of competencies:	- Cognitive competencies: holding basic acquirements from the field of chemistry & physics. - Action competencies – related to/concerning: information & documentation activities; group activities; argumentation and utilization of information technologies for data acquisition + processing of analytical data; realization of active and critical analyses; operationalization and application of the acquired knowledge. - Affective-attitudinal competencies: availability to imply himself in the didactic process in an active and inter-active manner; availability to design and realize complex experiments.

5. Conditions (when necessary)

5.1 For the course	• Course-dedicated room, which includes a PC, an associated video-projector and a multi-media system.
5.2 For the seminary/laboratory	• Laboratory with the appropriate analytical instrumentation, including various types of sensors.

6. Specific Competencies acquired

Professional competencies	• Knowledge, understanding, analysis and application – in both inter-disciplinary and trans-disciplinary perspectives – of those phenomena and processes related to analytical techniques based onto <u>sensors</u> used for investigation & monitoring of environmental quality. • Ability of making an appropriate and contextualized choice of most appropriate analytical methods / techniques, in compliance with both the concrete situations and the available resources. • Measurement of concentration levels for chemical pollutants, with emphasis on most important classes of chemical compounds and on field-used sensors – with emphasis on chemical sensors. • Choose of most appropriate sensors-based instrumental techniques for investigating the quality of a pollution-affected environment, function of both pollutant(s) and contaminated environmental compartments. • Acquiring useful practical skills related to measurement of chemical pollutants using most employed chemical sensors.
Transversal competencies	• Development of actional competencies – information and documentation, group activity, argumentation and use of information technology for both acquisition and processing of analytical data. • Competence of reflecting (individually and collectively) to various topics and problems. • Practicing cognitive flexibility. • Realization of an efficient communication (verbal and written). • Active and interactive participation of students to the teaching process in its integrality. • Methodological competencies: taking notes & their systematization, ordering, etc.; formulation of research topics/subjects; enunciation of problem-situations and their solving; establishing hypotheses and verifying them; drafting of texts; relationship with others and empathizing with them; collaboration and group work; involvement in the management of an activity.

7. Objectives of the discipline (based onto the acquired competencies)

7.1 General objective of the discipline	• Acquiring most relevant knowledge related to instrumental techniques of analysis that employ chemical sensors most often applied to detection & quantification of chemical pollutants present in environmental samples.
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7.2 Specific objectives	- Acquisition of basic knowledge related to sensors – definition, classification, uses, and main characteristics. - Systemic knowledge of analytical techniques that are based on sensors, usable for controlling environmental quality. Acquiring the basic concepts and principles with which the essential, most used in practice, instrumental analytical techniques based on chemical sensors operate. - Knowledge of the fields of applicability of main sensors-based analysis methods. Description of the principal categories of chemical sensors that can be used for investigating environmental samples. - Acquiring a set of practical skills specific to chemical analysis using instrumental methods using sensors, including their calibration.
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8. Contents

8.1 Course	Teaching methods	Remarks
This course introduces a number of sensor-related concepts, with a major focus on chemical sensors used in the investigation of environmental samples. Special attention is also paid to the sensor calibration process. For this purposes, both basic terminology (absolutely necessary as a starting point), as well as reasoning and examples (useful for deepening and understanding concrete issues) are provided. For increased accessibility, a large number of figures, schematics and tables were used, which facilitate a good grasp of the major impact that sensors have in general and in the control/monitoring of the environment in particular. By the type and multitude of information involved, this course is characterized by a high degree of inter-disciplinarity and trans-disciplinarity, as it includes & integrates various complex information from the fields of chemistry, physics, electronics, etc. CONTENT: 1. Introduction to sensors. Basic concepts. Sensors – definition, types/classification, their use in practice. [2 hours] 2. Essential characteristics of sensors. Sensitivity, specificity (and interferences), selectivity, instability (drift), detection limit, dynamic range. Lifetime. Calibration curve. [4 hours] 3. Chemical sensors: electrochemical sensors – 1. Potentiometric (ion-selective) sensors: ion-selective electrodes, glass, pH electrodes, electrochemical gas sensors. Uses. [2 hours] 4. Chemical sensors: electrochemical sensors – 2. Amperometric sensors (for O₂), conductivity (resistive) sensors, utilization. [2 hours] 5. Chemical sensors: conductive & capacitive sensors. Metal-oxide semiconductor sensors (with SnO₂) for gases; capacitive sensors for humidity. [4 hours]	Interactive lecture Demonstration Problem-based learning Problematization Exercises and problem solving Case studies presentation Heuristic conversation Explication	Attending the course is facultative, but highly recommended . Attending the applicative activities and seminars is mandatory. Number of absences accepted is maximum 20% of the total number of hours. Students that have a large number of absences at seminars/laboratory cannot attend the final exam.

6. Chemical sensors: calorimetric (thermal) sensors. Pellistor sensor – principle of operation, applications to combustible gases. [2 hours] 7. Chemical sensors: opto-chemical sensors (opt[r]odes). Opt[r]odes – operating principle, components of an optical system, uses. [2 hours] 8. Chemical sensors: sensors sensitive to mass variation. Piezoelectric sensors, SAW (Surface Acoustic Wave) sensors. Uses. [2 hours] 9. Chemical sensors: sensors based on atmospheric pressure ionization of compound vapors. "Green" sensors: PID (Photolonization Detection) sensors, IMS sensors (based on ion mobility spectrometry). Principle and utility. [4 hours] 10. Chemical sensors: sensor networks. Examples, principle of operation, components, uses. [2 hours] 11. Future trends in sensor development. New types of sensors, applications. [2 hours] <i>TOTAL: 28 hours / semester (2 hours / week × 14 weeks).</i>	Modeling	The individual written report is handed to course coordinator <i>before</i> the final exam. Plagiarism results in cancelling the student's written report.
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Bibliography:

a) Mandatory Bibliography:

1. Rouessac, F.; Rouessac, A., „*Chemical Analysis – Modern Instrumentation, Methods and Techniques*”, Third Edition, John Wiley & Sons, 2022.
2. Wilson, John S. (Editor), „*Sensor Technology Handbook*”, Elsevier, 2005.
3. Campbell, M. (Ed.), „*Sensor Systems for Environmental Monitoring – Volume One: Sensor Technologies*”, Springer Verlag, 1st Edition, 1997.
4. Campbell, M. (Ed.), „*Sensor Systems for Environmental Monitoring – Volume Two: Environmental Monitoring*”, Springer Verlag, 1st Edition, 1997.
5. Sberveglieri, G. (Ed.), „*Gas Sensors – Principles, Operation and Developments*”, Springer, 1st Edition, 1992.
6. **Course Support** – Assoc. Prof. Dr. Bocoș-Bințișan Victor.

b) Supplementary Bibliography:

1. Skoog, D.A.; Holler, F.J.; Nieman, T.A., „*Instrumental Analysis – 5th Edition*”, Saunders College Publishing, 1998.
2. Gopel, W.; Hesse, J.; Zemel, J.N. (Editors), „*Sensors – Vol.2: Chemical and Biochemical Sensors Part. 1*”, VCH Press, 1991.
3. Kekedy, L., „*Senzori electrochimici metalici și ion-selectivi*”, Ed. Academiei, București, 1987.
4. Luca, C.; Duca, Al.; Crișan, I. Al., „*Chimie analitică și analiză instrumentală*”, Editura Didactică și Pedagogică, București, 1983.
5. Lodge, James P. (Ed.), „*Methods of Air Sampling and Analysis*” (3rd Edition, CRC Press, Taylor & Francis, USA, 2000, 764 pag.
6. Kellner, Robert; Mermet, Jean-Michel; Otto, Matthias; Widmer, H. Michael, „*Analytical Chemistry: A Modern Approach to Analytical Science*”, 1st Edition, Wiley-VCH, 1997.

8.2 Seminar / laboratory	Teaching methods	Remarks
Content: 1. Sensors – A ubiquitous and growing presence in our daily lives. [2 hours] 2. Chemistry of low concentrations – a strict necessity & application to the control of environmental pollutants using sensors. Trace and ultra-trace analysis. [2 hours] 3. Calibration of instrumentation based on sensors - the basic elements. Preparation of analytical standards – in liquid phase and in gas phase. Standard atmospheres and their preparation using (a) static methods and (b) dynamic methods. [4 hours] 4. LABORATORY #1: Applications of semiconductor sensors. Rapid vapor determinations of VOC volatile organic compounds using SnO₂-based semiconductor sensors. [4 hours] 5. LABORATORY #2: Applications of electrochemical sensors. Rapid determinations of toxic gases using the MultiRAE Plus model multi-sensor analyzer. [4 hours] 6. LABORATORY #3: Applications of PID (photoionization) type sensors. Real-time determination of trace VOCs using an ultra-sensitive PID analyzer (sensitivity of 1 ppb_v). Monitoring the vapor dispersion of a volatile organic compound VOC in indoor air. [6 hours] 7. LABORATORY #4: Applications of IMS sensors (based on ion mobility). Rapid, real-time detection of ultra-trace organic compounds using an IMS ion mobility spectrometer. [2 hours] 8. LABORATORY #5: Instrumentation with an integrated set of sensors ("sensor array"). Case study – the ChemPro-100i instrument and its various uses. Rapid detection of a trace-level volatile organic compound (VOC) using the ChemPro-100i. [4 hours] <i>TOTAL: 28 hours / semester (2 hours/week × 14 weeks).</i>	Problem-based learning Experiments Problematization Exercises and problem solving Heuristic conversation Explication Modeling Case studies	Some experiments are accomplished in a demonstrative manner.
Bibliography: Similar to that presented at 8.1.		

9. Corroboration of the contents associated to discipline with the expectations of the representatives of epistemic community, professional associations and principal employers acting in the field related to the programme

- The discipline possesses strong inter-disciplinary and trans-disciplinary valences.
- The discipline is correlated currently to critical topics worldwide, such as detection and quantification of a wide range of pollutants & toxic substances.
- Therefore, this discipline offers the bachelor students the capacity to bring a contribution to solving complex problems related to chemical pollution of the environment.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the final grade
10.4 Course	Correctness of the answers	Exam (written test)	70%
	Capacity to identify problems having a critical status		
10.5 Seminar/laboratory	Capacity to apply the knowledge acquired to concrete situations	Lab written reports / portfolio. Continuous evaluation during the semester.	30%
	Capacity of problem solving and of integrating the acquired knowledge in the discipline with the acquisitions from related disciplines.		
10.6 Minimal standard of performance			
- Knowing the basic notions specific to this discipline and understanding the interdependencies between them. - Acquiring the operating principles of the main categories of chemical sensors, their characteristics, as well as acquiring skills related to sensor calibration/calibration. - Knowledge of the analytical techniques based on the use of the most common and used sensors - both in the laboratory and in the field. - Application of all mentioned acquisitions to solving problems and practical applications, with different degrees of complexity. Developing students' skills to draw calibration curves and work with them. - Systematic integration of the acquisitions from this discipline with acquisitions characteristic of other disciplines of the bachelor's degree study program.			

Date:

Signature of course coordinator

Signature of seminar coordinator




05.12.2024

Date of approval in the department

Signature of the Head of Department

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