Wrocław University of Science and Technology
Doctoral School

COURSE CARD

1. Basic information

Course name in English:	Smart Intelligent Chemical Engineering Fundamentals	
Course name in Polish:	Podstawy inteligentnej inżynierii chemicznej	
Number of hours:	30	
Type of course:	Elective course	
Form of course:	mixed forms (combination of lecture, seminar and laboratory)	
Code of course:		
Course leader:	Dr hab. inż. Anna Siekierka	
Faculty of the course leader:	W3 Faculty of Chemistry	
Email address of the course leader:	anna.siekierka@pwr.edu.pl	
Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course):	Architecture and urban planning	☐
	Automation, electronic, electrical engineering and space technologies	☒
	Information and communication technology	☐
	Biomedical engineering	☐
	Chemical engineering	☒
	Civil engineering, geodesy and transport	☐
	Materials engineering	☒
	Mechanical engineering	☐
	Environmental engineering, mining, and energy	☒
	Mathematics	☐
	Chemical sciences	☒
	Physical sciences	☒
	Management and quality studies	☐

2. Objectives

The course aims to provide doctoral students with foundational knowledge of Smart and Intelligent Chemical Engineering, focusing on the principles, tools and technologies enabling the transition from traditional chemical engineering toward autonomous, data-driven, adaptive and high-efficiency systems.
The objective is to introduce fundamental concepts such as:

- smart materials and intelligent separation units,
- algorithms and sensing technologies supporting real-time decision-making,
- digital twins, automation and AI frameworks applied in chemical engineering,
- conceptual understanding of how chemical processes evolve into cyber-physical systems.

Students will acquire competences necessary to understand, design and critically evaluate intelligent chemical engineering systems at the fundamental level.

3. Content

Detailed information about the course content, including topics and form of classes.

No.	Topic	Number of hours	Form of classes
1	Introduction to Smart & Intelligent Chemical Engineering	2	lecture
2	Intelligent Materials and Smart Interfaces: Basic Principles	4	lecture
3	Fundamentals of Smart Separation Technologies	2	lecture
4	Basic AI Concepts for Chemical Engineering	2	lecture
5	Digital Twins — Conceptual Foundations	2	lecture
6	System Integration in Intelligent Chemical Plants	6	seminar
7	Case Fundamentals: Intelligent Separation & Membrane Systems	6	seminar
8	Ethics, Sustainability & Safety Foundations in Smart Engineering	6	seminar
9			Select form
10			Select form
11			Select form
12			Select form
13			Select form
14			Select form
15			Select form

4. Prerequisites

List of prerequisites relating to knowledge, skills and other competences for course participants.

Participants should have:

- basic knowledge of chemical engineering principles (mass/heat transfer, unit operations, reaction engineering);

- ability to analyse scientific literature;

- elementary understanding of mathematical modelling;

- no advanced AI or programming background is required - the course covers only fundamentals.

5. Learning outcomes

List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).

Symbol	**Learning outcome**	
	KNOWLEDGE. Doctoral student knows and understands:	

SzD_W3	the main trends in the development of the scientific or artistic disciplines covered in the curricula;	☒
SzD_W4	research methodology;	☒
SzD_W5	the rules for the dissemination of scientific results, including in open access mode;	☒
SzD_W6	the fundamental dilemmas of modern civilization;	☒
SzD_W7	the legal and ethical conditions of scientific activity;	☒
SzD_W8	the economic and other relevant conditions of scientific activity;	☒
SzD_W9	basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results.	☒
	SKILLS. Doctoral student is able to:	
SzD_U2	use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular: - define the purpose and subject of scientific research, formulate a research hypothesis, - develop research methods, techniques and tools, and use them creatively, - draw conclusions on the basis of scientific research; critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development; transfer the results of scientific activities to the economic and social spheres;	☒
SzD_U3	communicate on specialised topics to the extent that they enable an active participation in the international scientific community;	☒
SzD_U4	disseminate research results, including in popular forms;	☒
SzD_U5	initiate debates and participate in a scientific discourse;	☒
SzD_U6	be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment;	☒
SzD_U7	plan and implement an individual or collective research or creative activity, including in an international environment;	☒
SzD_U8	independently plan and act for one's own development and inspire and organize the development of others;	☒
SzD_U9	plan classes or groups of classes and implement them using modern methods and tools.	☒
	SOCIAL COMPETENCES. Doctoral student is ready to:	
SzD_K3	fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way;	☒
SzD_K4	maintaining and developing the ethos of research and creative environments, including: - carrying out scientific activities in an independent manner, - respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection.	☒

6. Evaluation

Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.

- Final presentation showing understanding of a selected fundamental concept (50%)
- Activity during seminars (50%)

7. Teaching methods

Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.

multimedia lectures presenting basic concepts,

guided literature review,

case-based conceptual analysis,

group discussions,

introductory modelling demonstrations,

problem-solving sessions focusing on fundamental understanding.

8. Literature

List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.

A. B. P. Lever: Smart Chemical Engineering: Intelligent Materials and Systems, Springer.

R. C. Reid, M. Prausnitz, B. Poling: The Properties of Gases and Liquids (as a basis for modelling).

Recent review papers on smart membranes, digital twins, and AI in chemical engineering (Chemical Engineering Journal, AIChE Journal, Separation and Purification Technology).

Z. Zhang et al., “Machine learning in chemical engineering: State of the art.”

Papers on smart electrodialysis, adaptive process control, and intelligent separations.

Standards and industrial guidelines on process automation and monitoring.

9. Other remarks

Additional remarks, comments, (e.g., language of the course)