GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Urban mining, PG_00072444		
Field of study	Materials Engineering		
Date of commencement of studies	October 2023	Academic year of realisation of subject	2026/2027
Education level	first-cycle studies	Subject group	Obligatory subject group in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	4	Language of instruction	Polish
Semester of study	7	ECTS credits	2.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Division of Electrochemistry and Surface Physical Chemistry -> Institute of Nanotechnology and Materials Engineering -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	prof. dr hab. inż. Jacek Ryl	
	Teachers	dr Tomasz Swebocki	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	0.0	15.0	0.0	30
E-learning hours included: 0.0						

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	30	2.0	18.0	50

Subject objectives

The aim of this course is to familiarize students with the concept of urban mining and engineering methods for recovering valuable materials from selected waste streams, with particular emphasis on metals, critical raw materials, and functional materials. The course develops skills in designing and evaluating recovery processes, from identifying waste composition, through selecting separation and processing methods, to mass and energy balance, characterizing the secondary product, and assessing profitability and environmental impact.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K6_U06] Can integrate obtained information, interpret it and draw conclusions, as well as formulate and justify opinions.	The student is able to evaluate information on the composition, properties and processing possibilities of selected waste streams, interpret the results of material analyses and process balances, and formulate conclusions regarding the feasibility of recovering valuable materials.	[SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject
[K6_W03] Has knowledge of materials science and can relate the properties of materials with their structure and composition, knows the theoretical description of phenomena occurring in materials subjected to external factors.	The student knows the basics of urban mining, allowing them to link the composition, structure and properties of waste materials with the processes of recovering their valuable components.	[SW3] Assessment of knowledge contained in written work and projects [SW1] Assessment of factual knowledge
[K6_U01] Can properly use selected analytical, simulation and experimental methods, as well as devices for measuring the fundamental properties of materials and technological processes.	The student is able to select analytical and experimental methods to characterize waste streams, assess the effectiveness of separation and recovery processes and the course of the technological process.	[SU2] Assessment of ability to analyse information [SU4] Assessment of ability to use methods and tools

Subject contents	Course content – lecture 1. **Urban mining as a component of the circular economy:** Critical raw materials, secondary material sources, circular economy, raw material security. 2. **Selected waste streams and the material anatomy of complex products:** Electronics, batteries, cables, magnets, plastics, composites, construction waste, infrastructure. Bulk, valuable, critical, and problematic components. 3. **Material identification, waste characterization, and process balance:** Selected measurement techniques. Mass balance, recovery efficiency, product purity, losses, and basic energy balance. 4. **Comminution, screening, and physical separation methods:** Component release from the matrix, screening, magnetic separation, eddy current, electrostatic, gravity, optical/spectroscopic. 5. **Hydrometallurgy in metal recovery:** Leaching, precipitation, solvent extraction, ion exchange, solution purification, selectivity. 6. **Pyrometallurgy and High-Temperature Processes:** Smelting, roasting, pyrolysis, reduction, refining, and thermal treatment of organic and mineral matrices. 7. **Electrometallurgy and Electrochemical Recovery Methods:** Electrodeposition, electropurification, electrocoagulation, electrodialysis, electroleaching, and reagent regeneration. 8. **Case Study I: Batteries and Accumulators as a Complex Source of Raw Materials** 9. **Case Study II: Electronics, PCBs, wires, and magnets** 10. **Case Study III: Polymers, Composites, and Multicomponent Materials** 11. **Case Study IV: Construction Waste, Infrastructure, and Recycled Aggregates** 12. **Designing Materials for Recovery and Environmental and Economic Assessment:** Design for recycling, LCA, carbon and water footprint, recovery cost, energy and reagent consumption, profitability limits. Course content – project Design of a process for recovering valuable materials from a selected waste stream. Each group must design a metal recovery process from a different type of material (for example: PCB fragments, used zinc-carbon batteries, electrical wires, neodymium magnets from electronics, waste plastics, used electrodes). The project consists of a conceptual and laboratory component. During the laboratory component, critical steps of grinding/screening, separation, thermal treatment, precipitation, leaching, electrowinning, as well as TGA analysis, morphology, and composition will be performed. In the conceptual component, based on literature, own results, and a material balance, the student will assess and describe: the type of waste and valuable materials, the expected variability and technological risks, estimate treatment and recovery costs (mass and energy balance), characterize the secondary product, byproducts, evaluate profitability, and assess environmental impact.
Prerequisites and co-requisites	Surface physicochemistry, electrochemistry, materials science-related subjects
Assessment methods and criteria	see table below
Recommended reading	see below
Example issues/ example questions/ tasks being completed	1. Using a selected complex product as an example, identify the main material components, indicate valuable/critical components, and propose a possible recovery path. 2. Compare physical separation methods used in urban mining. 3. Design a simplified process flowchart for metal recovery from selected waste. 4. Explain what information can be obtained from the mass and energy balance of the recovery process and why it is essential for assessing the efficiency, cost-effectiveness, and environmental impact of the process. 5. Describe the basic aspects of LCA in relation to urban mining.
Practical activites within the subject	Not applicable

Assessment methods and criteria:

Subject passing criteria	Passing threshold	Percentage of the final grade
Project report	60.0%	40.0%
Test	60.0%	60.0%

Recommended reading:

Basic literature	S. K. Ghosh, **Urban Mining and Sustainable Waste Management**, Springer, 2020
Supplementary literature	JCR-listed articles, such as: • A comprehensive review on the recycling of spent lithium-ion batteries: Urgent status and technology advances (10.1016/j.jclepro.2022.130535) • An overview of NdFeB magnets recycling technologies (10.1016/j.cogsc.2024.100884) • Can e-waste recycling provide a solution to the scarcity of rare earth metals? An overview of e-waste recycling methods (10.1016/j.scitotenv.2024.171453) • Physicochemical reactions in e-waste recycling (10.1038/s41570-024-00616-z) • A comprehensive review of urban mining and the value recovery from e-waste materials (10.1016/j.resconrec.2022.106840)
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