GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Design of technological processes, PG_00060867		
Field of study	Chemical Technology		
Date of commencement of studies	October 2023	Academic year of realisation of subject	2025/2026
Education level	first-cycle studies	Subject group	Obligatory subject group in the field of study Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	3	Language of instruction	Polish
Semester of study	5	ECTS credits	2.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Process Engineering and Chemical Technology -> Faculty of Chemistry -> Wydziały Politechniki Gdańskiej		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Robert Aranowski	
	Teachers	dr inż. Robert Aranowski	

Lesson types and methods of instruction

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

eNauczanie source address: https://enauczanie.pg.edu.pl/2025/course/view.php?id=1070

Moodle ID: 1074 Projektowanie procesów technologicznych, Technologia Chemiczna, 2025/26-1 https://enauczanie.pg.edu.pl/2025/course/view.php?id=1074

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	1.0	19.0	50

Subject objectives

1. Develop the ability to develop chemical process concepts and technical problems.
2. Integrate knowledge of chemistry, safety, patents, and preliminary technological feasibility.
3. Develop teamwork skills with role allocation, project responsibility and timeliness, and constructive feedback.

Learning outcomes	<table><tr><th>Course outcome</th><th>Subject outcome</th><th>Method of verification</th></tr><tr><td>[K6_K02] understands the non-technical aspects and implications of the activities of a chemical engineer, including the impact on the environment, is aware of professional behaviour, observance of professional ethics and respect for diversity of views and cultures</td><td>The student is able to indicate the main impacts of a selected process (emissions, sewage, waste, energy/water consumption) and propose mitigation measures.</td><td>[SK5] Assessment of ability to solve problems that arise in practice</td></tr><tr><td>[K6_W06] has knowledge of information technology and computer-aided design, the use of databases in technological design</td><td>Student knows key databases (e.g. DIPPR, NIST), how to cite literature and source management software.</td><td>[SW3] Assessment of knowledge contained in written work and projects</td></tr><tr><td>[K6_W05] has knowledge of chemical technology based on mineral or energy resources and modern energy sources, understands the concept of sustainable development, knows the principles of green chemistry and environmentally friendly process engineering, has knowledge of occupational safety in the chemical industry</td><td>Understands the basics of the product life cycle (system boundaries, impact categories), emission monitoring (air, water, waste) and formal requirements (water legal report) – at a conceptual level.</td><td>[SW3] Assessment of knowledge contained in written work and projects</td></tr><tr><td>[K6_U04] performs basic design calculations of selected processes and unit operations, is able to calculate and select the basic apparatus of chemical industry in a process line</td><td>Student is able to formulate assumptions, select a thermodynamic model and perform mass and energy balances for the designed process.</td><td>[SU1] Assessment of task fulfilment</td></tr></table>
Subject contents	Lecture Contents: 1. Introduction to process design. The essence of process design. The design cycle. 2. Scientific and patent sources. Industrial property protection. Literature and patent databases; novelty/ inventive step; operational freedom; the impact of patent protection on process path selection. 3. Design documentation principles and standards. Laboratory procedures, design assumptions, structure of process documentation. 4. Process chemical concept technological choices. Selection of reactions, separation methods, and process type (continuous/batch) in conjunction with operational requirements. 5. Project chemical concept assessment of the suitability of chemical transformations in terms of thermodynamics, kinetics, and cost. 6. Environmental impact of the installation. Wastewater, waste, off-gases, and their utilization. 7. Perspective flow diagram (PFD). Symbols, standards, conventions, stream numbering. 8. Process flow diagram (P&ID). Process nodes. 9. Material and energy balance. Principles of preparation and presentation in design documentation. Sankey diagram mass and heat flows. 10. Selection of construction materials and corrosion protection. 11. Health and safety and the environment: occupational health and safety, fire hazards. HAZOP hazard analysis. 12. Selection of apparatus and equipment. Primary and auxiliary equipment. Equipment cycle schedule. 13. Process control concept. Selection of measurement and actuator devices. 14. Economic analysis of the project preliminary justification. CAPEX, OPEX, manufacturing cost, simple sensitivity analysis, cost risks. 15. Project presentation. Project Activities: 1. Project Selection and Conceptual Framework 2. Review of literature and patent information. Identification of known chemical synthesis pathways and industrial property restrictions. 3. Analysis of the thermodynamics and stoichiometry of proposed synthetic pathways. Preliminary assessment of the chemical feasibility of proposed reactions. 4. Kinetics, catalysis, and selectivity of proposed chemical reactions. Assessment of the yield/selectivity and catalytic requirements of product synthesis. Decision matrix of synthetic pathways. 5. Concept of possible separation and waste management methods. 6. Chemical concept selection and justification. 7. Preparation of a process schematic diagram.

<table>
<tr><td>Prerequisites and co-requisites</td><td colspan="2">
1. Stoichiometry and Balances: Simple mass balances for systems with and without reactions; concepts of conversion, selectivity, and yield.
2. Chemical Thermodynamics (Basic): ΔH, ΔG, chemical equilibrium, and the T/P effect (Le Châtelier's Principle); basic properties of mixtures (ρ, μ, Cp).
3. Basic Kinetics and Reactor Science: Reaction Orders, Rates.
4. Safety: Ability to analyze SDSs, basic hazards (flammability, toxicity), and DNSH principles.
5. Working with Literature and Patents: Searching for publications/patents, identifying novel and similar solutions.
6. Calculations: Spreadsheet proficiency (tables, graphs, simple formulas); basic knowledge of Scilab/ Matlab is desirable.
7. Team Communication: Working in groups of 23 people, basic role allocation.
8. Software Knowledge: Spreadsheet (Excel/LibreOffice) + word processing (Word/LaTeX). Schematic sketching tool (AutoCAD). Bibliography manager (Zotero/Mendeley).
9. Access to online university libraries (literature, optional databases).
</td></tr>
<tr><td>Assessment methods and criteria</td><td colspan="2">
<table>
<tr><td>Subject passing criteria</td><td>Passing threshold</td><td>Percentage of the final grade</td></tr>
<tr><td>Project presentation</td><td>60.0%</td><td>70.0%</td></tr>
<tr><td>Activity (mini quizzes)</td><td>60.0%</td><td>15.0%</td></tr>
<tr><td>Colloquium - lecture</td><td>60.0%</td><td>15.0%</td></tr>
</table>
</td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td>
1. Marchildon, K., & Mody, D. (2018). Practical process design for chemical engineers. Wiley.
2. Smith, R. (2016). Chemical process design and integration (2nd ed.). Wiley.
3. Turton, R., Bailie, R. C., Whiting, W. B., Shaeiwitz, J. A., & Bhattacharyya, D. (2018). Analysis, synthesis, and design of chemical processes (5th ed.). Pearson.
</td></tr>
<tr><td>Supplementary literature</td><td>
1. Green, D. W., & Southard, M. Z. (Eds.). (2019). Perrys chemical engineers handbook (9th ed.). McGraw-Hill Education.
2. Seider, W. D., Seader, J. D., Lewin, D. R., Widagdo, S., Gani, R., & Ng, M. K. (2017). Product and process design principles: Synthesis, analysis and evaluation (5th ed.). Wiley.
</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="2">
Process Description

A continuous, exothermic process involving the reaction A + B C is conducted in a stirred-tank reactor equipped with a cooling jacket. The two liquid raw materials (A and B) are transferred from storage to a buffer tank and then pumped into the reactor. The temperature is maintained by a cooling loop (chilled water). Product C flows by gravity into the receiver. The process is conducted under a nitrogen atmosphere. Overpressure protection is provided by a safety valve. The reactor is degassed via a carbon column.

A process flow diagram (P&ID) must be designed and drawn, including:

Equipment:

R-101: 2 m³ stirred-tank reactor, SS316L, PN16, jacketed; Agitator on M-101 (motor)
E-101: heat exchanger (reactor jacket medium: chilled water 510°C)
P-101A/B: feed pump (duplex, A/B)
TK-101: buffer tank (raw materials)
TK-102: product receiver
N2 cylinder: regulator + pressure maintaining valve
AC-101: activated carbon filter on the vent

Process line: A and B supply, emergency discharge, product discharge, vent.
Media line: chilled water (CWch), nitrogen, compressed air for instruments (I/A).
Fittings: shut-off valves, check valves, control valves (including cooling), drains, bypasses. Instrumentation and Control (ISA):
TIC-101: Reactor temperature control (TIR-101 measurement in the reaction mass, TV-101 actuator on the jacket cooling)
LIC-101: Reactor level control, controls the LV-101 discharge valve
FIC-101/102: A and B flow rate control (with FE-X flow meters and FV-X valves). A B/A flow ratio controller can be added. PIC-101: N overpressure maintenance (PV-101 valve on N supply)
Alarms: TAHH-101 (HH temperature), LAHH-101 (HH level), LALL-101 (LL level)
Safety: PSV-101 + RD-101 to AC-101 (venting)
ESD-101: emergency shutdown (pump stop, FV-101/102 closure, QV-101 emergency discharge opening)

Input Data

Raw material A: ρ=850 kg/m³, T=25 °C; B: ρ=970 kg/m³, T=25 °C
Product C: nominal T 40 °C; R-101 reactor: 2 m³, operating 6080% full
Operating pressure 1.3 bar(g), test pressure 6 bar(g), connection class PN16
Media: Chilled water 510°C, nitrogen 3 bar(g) (after reduction), I/A 6 bar(g)
Required flow rates (operating point): A = 200 kg/h, B = 300 kg/h
Materials: ASI 316L steel for process media, carbon steel for chilled water
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<tr><td>Work placement</td><td colspan="2">Not applicable</td></tr>
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