Lodz University of Technology

Chemical Engineering in the Petrochemical Industry

Course description

Basic information

Study programme
Occupational Safety Engineering

Speciality/path
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Organizational unit
Faculty of Process and Environmental Engineering

Study level
first-cycle programme (inżynier)

Study mode
full-time studies

Education profile
general academic

Didactic cycle
2026/27

Course code

Language of instruction
polish

Obligatory
Optional

Block
Directional subjects

Course related to scientific research
Yes

Course coordinator	Piotr Owczarz
Course instructor(s)	Piotr Owczarz, Mariola Błaszczyk, Anna Rył, Jarosław Sowiński, Bertrand Jóźwiak

Period	**Form of verification**	**Total ECTS points**
Semester 3	Exam **Classes and hours** • Lecture: 30 • Tutorials: 30 • Laboratory classes: 30	7

Prerequisites

Knowledge of Mathematics I, Physics I and Introduction to Mathematical Analysis, fundamentals of differential calculus and the ability to solve systems of differential equations.

Learning outcomes

Code	Programme outcomes	Detailed outcomes indicators
1IBP1	Has knowledge of basic and applied sciences necessary to solve problems in the field of occupational safety engineering.	1IBP1.1 Defines and describes basic concepts, theories, and relationships in basic and applied sciences relevant to occupational safety engineering.
1IBP2	Has detailed knowledge of labor law, hazard factors, safeguards and protective measures, ergonomics, occupational accidents and diseases, industrial accidents, industrial process safety, technical and medical rescue, necessary to ensure and improve safe and hygienic workplace conditions.	1IBP2.2 Lists the principles of safe work and operation of machines, devices, and industrial installations.
1IBP5	Is able to obtain and analyze information from various sources, plan and conduct experiments, analyze technical and organizational solutions, interpret the results obtained, make conclusions, participate in discussions, debates, and prepare documentation related to occupational health and safety requirements in the company.	1IBP5.2 Plans and conducts experiments, including measurements and computer simulations, analyzes and interprets the results obtained, draws conclusions, and prepares documentation.
1IBP8	Is able to take into account systemic and non-technical aspects (moral, economic, environmental, and legal) in the performance of occupational safety engineering tasks, as well as plan and implement activities individually and as part of a team, and possesses the ability to acquire new knowledge.	1IBP8.2 Cooperates with others in teamwork (including interdisciplinary teams), performing various roles depending on the needs of the group.

Course contents

Technological processes used in the petrochemical industry. Mass, heat, and momentum transfer in the context of chemical engineering process design and optimization.

Complementary information

Contents - detailed selection

No.	Contents - detailed selection	Class type
1.	Introduction to the petrochemical industry Definition and scope of the petrochemical industry. The role of chemical engineering in the refining and petrochemical sectors. Basic types of raw materials: crude oil, natural gas, refinery fractions. Main products: fuels (gasoline, diesel oil, LPG, aviation fuels), basic petrochemicals (ethylene, propylene, benzene, toluene), plastics, synthetic fibres, detergents.	Lecture
2.	Raw materials and their characteristics Structure and composition of crude oil. Physical properties of crude oil fractions: gasoline, kerosene, gas oil, oil fractions, heavy residues (fuel oil, asphaltenes). Natural gas: composition (methane, ethane, propane, butane, hydrogen sulphide), purification methods.	Lecture
3.	Fundamentals of fluid mechanics 1. Physical properties of fluids. Viscous stresses in real fluids. Basic rheological models of fluids. Equations of fluid motion and Navier–Stokes equations. Flow of viscous fluids in pipes and liquid film flow on walls. 2. Continuum hypothesis. Material point and fluid element. Forces acting in fluids. Hydrostatic pressure. Fluid equilibrium equations. Potential of body forces. Equipotential surfaces. Static pressure force. Buoyancy force and conditions of floating bodies. 3. Fundamentals of fluid dynamics: Euler equation, Bernoulli equation for ideal and real fluids. Characteristics of laminar and turbulent flow. Reynolds hypothesis and turbulence intensity. Averaged transport equations. Reynolds stresses. Universal velocity distribution of fluids.	Lecture
4.	Construction, operating principle and performance characteristics of centrifugal pumps Characteristics of pump systems connected in series and parallel. Pump selection for pipelines. Gas flow in pipelines. Characteristics of hydraulic systems: pump–pipeline, pressure tank–pipeline, and pump–pressure tank–pipeline systems.	Lecture
5.	Extraction and pipeline transport processes • Extraction from wells • Oil washing from shales • Transport of non-Newtonian liquids • Generalised Reynolds number, calculation of flow resistance for non-Newtonian fluids, etc.	Lecture
6.	Fundamentals of heat transfer • Heat transfer mechanisms • Heat conduction through flat and cylindrical walls, single- and multilayer • Heat transfer coefficient • Heat exchangers, methods for calculating the logarithmic mean temperature difference	Lecture
7.	Fundamentals of mass transfer	Lecture
8.	Refinery processes – physical processes of crude oil processing • Atmospheric distillation • Vacuum distillation • Binary and multicomponent rectification • Solvent extraction • Absorption and adsorption	Lecture
9.	Refinery processes – conversion processes of crude oil processing • Thermal cracking • Catalytic cracking (FCC) • Catalytic reforming • Isomerisation • Alkylation • Steam cracking – basis for ethylene and propylene production	Lecture

No.	Contents - detailed selection	Class type
10.	Key apparatus and equipment used in the petrochemical industry • Distillation columns (tray and packed) • Reactors: tubular, fluidised bed (FCC), catalytic reactors • Heat exchangers • Process furnaces (pyrolysis, reforming) • Separators and tanks • Compressors and pumps	Lecture
11.	Fundamentals of petrochemical process design • Mass and energy balances • Phase equilibrium in multicomponent systems • Selection and modelling of chemical reactors • Reaction mechanisms and chemical kinetics • Role of process simulation (e.g. Aspen Plus, HYSYS)	Lecture
12.	Fluid mechanics module • Rheometry and rheology of Newtonian and non-Newtonian liquids • Determination of pressure drops in straight and branched pipelines and local resistances • Study of solid particle settling in liquids • Study of parameters of two-phase gas–liquid flow • Determination of characteristics of centrifugal pumps and pump sets connected in series and parallel • Study of liquid outflow from a tank and determination of the discharge coefficient Pneumatic transport • Water hammer	Laboratory classes
13.	Heat transfer module • Study of heat exchangers, temperature distribution for co-current and counter-current exchangers • Liquid boiling	Laboratory classes
14.	Mass transfer module • Mass transfer in the gas phase • Rectification in a packed column • Drying process kinetics	Laboratory classes
15.	Calculation of flow and local resistances Flow of Newtonian fluids in fully filled pipes and open channels. Characteristics of single pipelines and pipeline systems connected in series and parallel.	Tutorials
16.	Heat transfer calculations • Heat conduction through flat and cylindrical walls, single- and multilayer; heat flux and temperature distribution calculations • Convective heat transfer; calculation of heat transfer coefficients for multilayer flat and cylindrical walls • Heat exchanger calculations, methods of logarithmic mean temperature difference	Tutorials
17.	Calculations related to mass transfer: Representation and conversion of concentration units. Diffusion coefficients in the gas and liquid phases. Equimolar counter-diffusion. Diffusion of one component through a stationary (inert) second component. Mass transfer and mass penetration. Mass transfer and mass penetration coefficients. Absorption equilibrium. Counter-current absorption, co-current absorption, mass balance. Humidification and drying of air, relative humidity and absolute humidity. Distillation and rectification, process mass balance, determination of the number of theoretical stages, determination of the height equivalent to a theoretical plate (HETP).	Tutorials

Teaching methods and techniques, passing conditions

Class type	Teaching methods and techniques	Passing conditions
Lecture	Multimedia presentation, Lecture	Written examination based on the lecture. A prerequisite for passing is obtaining a positive grade, i.e. achieving at least 60% of the total available points.
Tutorials	Creative problem-solving, Practice method	The requirement for passing the practical classes is obtaining a positive grade (minimum 60% of the total available points) in each of the two written tests conducted during the semester. • The first test covers fluid statics and fluid dynamics, and the grade obtained accounts for 40% of the final grade for the practical classes. • The second test covers basic heat transfer calculations (energy balances, determination of heat transfer and heat penetration coefficients, fundamental calculations of heat exchangers) as well as mass transfer topics (conversion of concentrations, determination of diffusion coefficients, mass balances of absorption, distillation, and rectification processes, and basic calculations of equipment used in mass transfer operations), the grade from the second test constitutes 60% of the final grade for the practical classes.
Laboratory classes	Group work, Laboratory/computer-based exercises	The requirement for passing the course is obtaining a positive grade from: • Oral assessments for all laboratory experiments performed. The averaged grade from the oral tests constitutes 15% of the final course grade (60% of the laboratory grade). • A positive grade for a substantive laboratory report prepared in laboratory groups, which constitutes 10% of the final course grade (40% of the laboratory grade). The instructor may differentiate the final report grades by taking into account ongoing observation of the student’s performance during laboratory classes, including, among others, active participation in laboratory work and contribution to the development and analysis of results.

Examination methods, weighed grades

Class type	Examination methods and weighed grades
Lecture	Written assignment: 50%
Tutorials	Written assignment: 25%
Laboratory classes	Speaking assignment: 15% Research results: 10%

Verification of learning outcomes

Detailed outcome indicators	Verification criteria	Assesment tool (class type)
1IBP1.1	Written examination (test) A positive grade is awarded when the student: • is able to correctly define basic concepts of fluid mechanics, heat transfer, and mass transfer; • is able to define a problem and perform basic calculations in the field of fluid statics; • is able to define a problem and perform basic calculations in the field of fluid dynamics; • is able to define a problem and perform basic calculations in the field of heat transfer; • is able to define the fundamental relationships required to perform energy balances and heat exchanger calculations; • is able to define a problem and perform basic calculations in the field of mass transfer; • selects appropriate separation and purification processes for raw materials in the petrochemical industry (e.g. filtration, extraction, distillation, rectification, crystallization, centrifugation, etc.) and justifies the selection based on differences in the physical properties of the raw materials; • selects appropriate separation and purification processes for products in the petrochemical industry (e.g. filtration, extraction, distillation, rectification, crystallization, centrifugation, etc.) and justifies the selection based on differences in the physical properties of the products.	Written assignment (Lecture, Tutorials), Research results (Laboratory classes)
1IBP2.2	A positive grade is awarded when the student: • is able to define the fundamental requirements for the safe operation of petrochemical processes, including the identification of key process parameters (e.g. temperature, pH, pressure, time, heating and mixing intensity, concentrations, flow rates) and describes how these parameters affect process safety; • takes into account industrial-specific aspects, including scale-up, process safety, quality requirements, and the risk of contamination, particularly in the context of production of petrochemical products.	Speaking assignment (Laboratory classes)
1IBP5.2	A positive grade is awarded when the report: • includes a comparison of experimental results with at least one literature source and/or a theoretical model (presented in the form of tables and/or graphs); • presents the comparison methodology (e.g. relative error, uncertainty intervals, curve fitting) along with correct calculations; • includes an interpretation of discrepancies, taking into account the influence of experimental conditions, model simplifications, measurement quality, uncertainties, and systematic errors; • formulates conclusions, addressing whether the results are consistent within an acceptable range and what this implies for the validity of the research and/or the applied method; • interprets the results with respect to the aim and hypothesis of the study and indicates their scientific and practical significance.	Speaking assignment (Laboratory classes), Research results (Laboratory classes)
1IBP8.2	Processing and analysis of experimental results A positive grade is awarded when the student: • is able to work effectively in a group and, through joint discussion, interprets the results with respect to the aim and hypothesis, while indicating their significance; • actively participates in laboratory classes as well as in the processing of the obtained results and the preparation of the report, as assessed on the basis of the instructor’s observation.	Research results (Laboratory classes)

Literature

Compulsory reading

1. M. Dziubiński, J. Prywer, Mechanika płynów dwufazowych, WNT, Warszawa 2010
2. Orzechowski Z., Prywer J., Zarzycki R.: Zbiór zadań z mechaniki płynów w inżynierii środowiska. WNT, Warszawa, 1997
3. M. Serwiński, Zasady inżynierii chemicznej. PWN Warszawa, 1981
4. Z. Kembłowski, S. Michałowski, Cz. Strumiłło, R. Zarzycki, Podstawy teoretyczne inżynierii chemicznej i procesowej, WNT, Warszawa 1985
5. Instrukcja do każdego z wykonywanych ćwiczeń laboratoryjnych
6. Zarzycki R., Prywer J.,:Mechanika Płynów, PWN, Warszawa, 2022
7. Zarzycki R.: Wymiana ciepła, PWN, Warszawa, 2020
8. Zarzycki R.: Dyfuzyjny ruch masy, PWN, Warszawa, 2020

Other reference materials

1. Faghri A., Zhang Y., Transport phenomena in multiphase systems, Elsevier, Amsterdam 2006
2. Douglas J.F., Solution of Problems in Fluid Mechanics, Pitman Publishing Inc., London 1982

Research and publications

1. Kembłowski, Z., Fidos, H., Kiljański, T., Dziubiński, M., Owczarz, P., Budzyński, P., ... & Strzelecki, W. (2003). Własne konstrukcje specjalnych typów reometrów do badania mediów o złożonych właściwościach reologicznych. Przemysł Chemiczny, 82, 1203-1205.
2. Rył, A., & Owczarz, P. (2020). Injectability of thermosensitive, low-concentrated chitosan colloids as flow phenomenon through the capillary under high shear rate conditions. Polymers, 12(10), 2260.

Student workload

Activity type	**Average number of hours* needed to complete an activity**
Lecture	30
Tutorials	30
Laboratory classes	30
Preparation for the laboratory	20
Preparation for tutorials	20
Preparation of a report	20
Participation in academic consultations	10
Preparation for the final exam	40
Total student workload	**No. of hours** 200
Workload involving teacher	**No. of hours** 90

Total ECTS points	ECTS 7

* activity hour equals to 45 minutes

Directional learning outcomes

Code	Content
1IBP1.1	Defines and describes basic concepts, theories, and relationships in basic and applied sciences relevant to occupational safety engineering.
1IBP2.2	Lists the principles of safe work and operation of machines, devices, and industrial installations.
1IBP5.2	Plans and conducts experiments, including measurements and computer simulations, analyzes and interprets the results obtained, draws conclusions, and prepares documentation.
1IBP8.2	Cooperates with others in teamwork (including interdisciplinary teams), performing various roles depending on the needs of the group.