Chemical and Process Technology elective package

Chemical and Process Technology	
Offered by	Department of Chemical Engineering and Chemistry (CE&C)
Language	English
Primarily interesting for	Students with background in Chemical Engineering and Chemistry.
Prerequisites	Required courses: 6A3X0, 6A4X0, 6A6X0, 6P1X0, 6P2X0, 6P3X0
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Content and composition

In process technology, a thorough understanding of the various aspects that play a role in the design of sustainable new chemical processes or the adjustment or upgrading of existing processes is essential – for instance, the comparison of alternative process routes, selection and design of the various pieces of equipment, optimization of operating conditions and evaluation of opportunities for process innovation and intensification. The Process Technology cluster offers a coherent elective package that teaches basic knowledge and skills of process technology through the courses “Numerical methods”, “Process dynamics and control” and “Process design”.

The “Numerical methods” course looks at numerical solutions from various linear or non-linear algebraic and differential equation systems. This course focuses on the backgrounds to the various numerical methods and the implementation in a suitable programming environment of typical problems relating to process technology. “Numerical methods” constitutes the backbone for the two other elective courses, which depend on the correct solution of system equations. In process design, it is often necessary to solve linear and/or non-linear equation systems, while process dynamics is more concerned with solving differential equations.

The “Process design” course, which consists largely of Design-Based Learning, aims to lead to a concrete design for chemical process plants, and centers on the accumulation of insight into the combination of factors that determine an optimal process design, and the setting up of alternative process routes. In addition, students will gain proficiency in the use of flowsheeting software for process simulation, particularly for calculating stationary energy and mass balances and the scaling and dimensioning of equipment.

The “Process dynamics and control” course shifts the emphasis to dynamic process behavior. Understanding dynamic systems helps us to arrive at a suitable control strategy, commonly aimed at ensuring the safety and/or performance of the chemical process system. The main objective here is to set up dynamic process models to be applied in the Laplace domain so that they can be easily used for simulation purposes and for setting feedback controls. The “Process design” and “Process dynamics and control” courses converge in the area of plant-wide control, which is an integral part of process design. In the last stage of conceptual process design, attention is often paid to the controllability of the system (what can be controlled and how, without conflicts arising).

Course code[i]	Course name	Level classification
6E5X0	Numerical methods*	2
6E8X0	Process dynamics and control**	3
6E9X0	Process design**	3

* This course will be taught for the last time in academic year 2023/2024. For the academic year 2024/2025, two more attempts for the final exam will be offered.[1]

** This course will be taught for the last time in academic year 2024/2025. For the academic year 2025/2026, two more attempts for the final exam will be offered.[1]

[1] The extra two attempts are exclusively for students that already did the final exam, but had an insufficient final grade.

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Course description

Numerical methods for chemical engineers, 6E5X0

This course familiarizes students with numerical methods. By the end of the course, students will be able to understand and solve systems of linear and non-linear equations, ordinary and partial differential equations and combinations of these. Data analysis and optimization will also be considered. In this course, the backgrounds to the numerical methods will be introduced and practiced and the various methods compared using Microsoft Excel. Subsequently, MATLAB will be used as a programming environment for solving practical process technology-related test cases from physical transport phenomena, reactor engineering and separation technology. The course addresses the following topics:

- errors in computer simulations;
- linear algebraic equations: matrix calculations (inverse, determinant, eigenvalues), Gauss elimination, Partial Pivoting, LU factorization, sparse systems, iterative methods (Jacobi);
- non-linear algebraic equations: a.o. Newton's method, Broyden's method;
- differential equation systems: Euler's method, Runge-Kutta methods, implicit methods;
- Optimization and data interpolation and regression.

Process dynamics and control, 6E8X0

The field of process control and dynamics integrates various disciplines, such as physical transport phenomena, thermodynamics, process design, mathematics and control theory. This field centers on the development of dynamic models. Insight into the dynamics of processes leads to control strategies that can be used to control chemical processes, so as to ensure safety, product quality and compliance with environmental regulations. In addition, the implementation of process regulators often serves to compensate for deficiencies that have arisen in the process design. The course addresses the following topics:

- formulation of the control objective for a process;
- development of mathematical process models;
- linearization and Laplace transformation of models;
- derivation of transfer functions;
- estimation of dynamic process behavior;
- process simulation in Matlab Simulink;
- dynamics of controlled processes;
- design of process control mechanisms and tuning of process controls.

Process design, 6E9X0

This lecture envisages the concrete design of chemical process plants, and covers proficiency in the use of flowsheeting software, the setting up of alternative process routes and the acquisition of insight into the combination of factors that determine optimal process design as core competences. The design process is examined on three levels:

1. conceptual process design using professional software (AspenPlus): setting up alternative process routes, process simulation, process synthesis
2. detailed process design: heat integration (pinch technology)
3. equipment design (dimensioning of a reactor, a number of separation stages and peripheral devices such as pumps, compressors and heat exchangers)

Particular attention will be paid to the quantitative design of a chemical process, including mass balances and energy balances (i.e. integration of knowledge already acquired in courses such as physical transport phenomena, reactor engineering, separation technology and numerical methods for chemical engineers); determining equipment dimensions for manufacturing a product with the desired properties and testing the resultant design for safety and ecological and economic feasibility. The course will be tested using a substantial case study that is to be solved as a team. The case will be based on a laboratory protocol or a short process description for which a detailed process diagram must be elaborated, paying attention to reactor selection and synthesis of separation trains, followed by an economic profitability analysis (capex and opex) of the designed process.