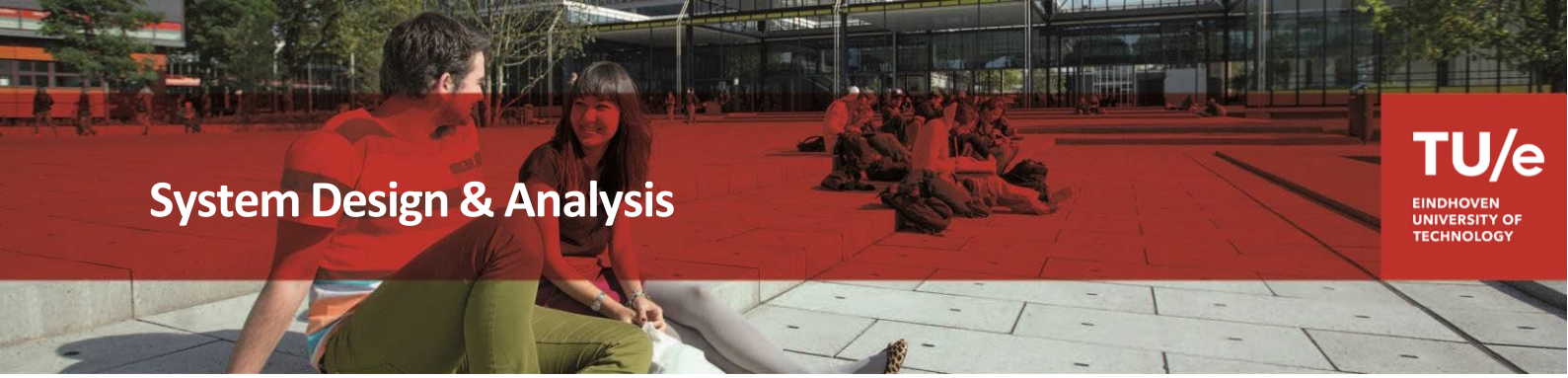


System Design & Analysis

System Design & Analysis	
Offered by	Department of Electrical Engineering
Language	English
Primarily interesting for	All students, but most relevant for students with background in Electrical Engineering, Computer Science, Automotive, Mechanical Engineering
Prerequisites	Elementary knowledge of basic set theory, basic probability theory, andbasic computer architecture
Contact person	Prof.dr.ir. A.A. (Twan) Basten, a.a.basten@tue.nl

Content and composition

In the systems design and analysis elective package, you learn about (i) architecture, design, and workings of complex systems and (ii) how to use models to design and analyze systems. The package brings together four courses, from which any combination of three courses can be chosen. The Q2 Design-Based Learning (DBL) course Electronic-Systems Engineering covers the systems engineering process, using the industry-grade SysML formalism for documenting the design of a manufacturing system and performance analysis to support design-space exploration. Operating systems are an important part of many systems. The Q2 Operating Systems course introduces operating-system architecture and reasoning about interacting concurrent programs. The Q3 Stochastic Performance Modeling course treats the analysis of queuing phenomena as they occur in for example traffic, production systems, and communication systems. The Q4 Computational Modeling course covers models of computation for embedded and cyber-physical systems, their analysis methods and application to system design and synthesis. Guaranteeing functional correctness and appropriate performance of the systems at hand forms a common thread through all courses in the package.

Course code	Course name	Level classification	Last year course is offered	Last year exam is offered
5XIC0	DBL Electronic-Systems Engineering	Deepening	NA	NA
2INC0	Operating Systems	Advanced	NA	NA
2WB60	Stochastic Performance Modeling	Deepening	2023-2024	2024-2025
5XIE0	Computational Modeling	Advanced	NA	NA

Learning objectives

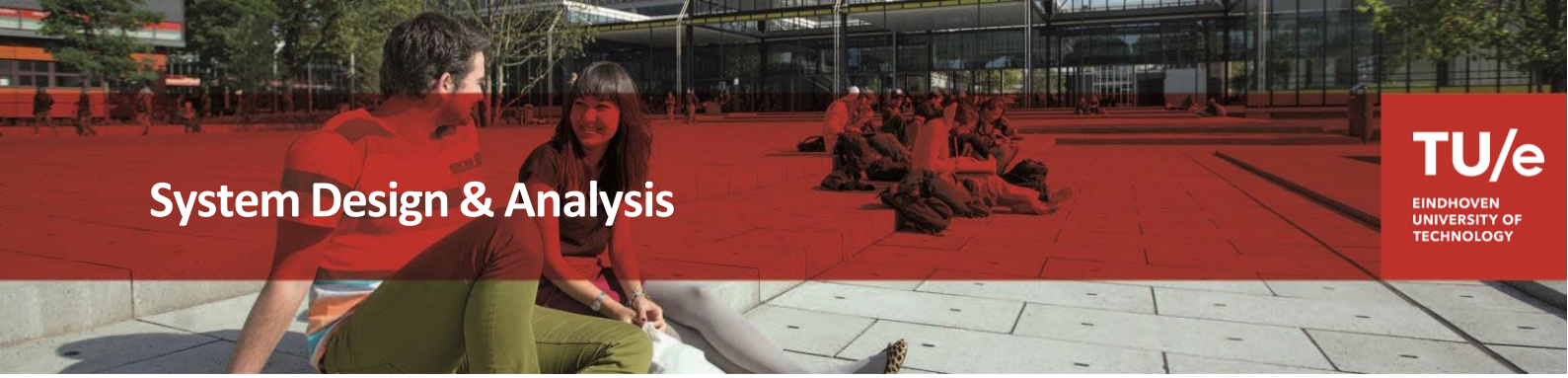
After completion of this elective package, a student should be able to

- **reason** about the architecture, design, and workings of complex systems;
- **reason** about functionality and extra-functional properties (such as performance) of systems;
- **explore** system-level trade-offs in the design of such systems using models;
- **choose** the appropriate modeling technique for the design question at hand;
- **create** analytical and simulation models for behavior, functionality, and performance of complex systems.

Course descriptions

DBL Electronic-Systems Engineering (5XIC0)

System thinking is essential to ensure a proper embedding of a system in its societal or industrial context. This course guides students in executing a model-based design process of a manufacturing system, going through requirements, architecting, design and validation phases. The course introduces the key systems engineering concepts, covering among others design processes such as the waterfall, V, spiral, and NASA models. The systems design notation SysML is introduced as a basis for documenting the design process. Performance modeling techniques are introduced to support model-based exploration of cost-performance trade-offs in the system design.



System Design & Analysis

Operating Systems (2INC0)
Introduction of concurrency, atomicity and interference. Program traces and interference. Reasoning about concurrent programs using traces, invariants and assertions. Standard problems like mutual exclusion, bounded buffer and readers/writers. Synchronization using semaphores, conditional critical sections and monitors. Hardware primitives. Global description of operating system tasks. Operating System architecture and Application Programmers Interface. The kernel, multiprocessing, interrupts, device drivers, implementation aspects. Virtual memory: demand paging, replacement algorithms. Resource management, scheduling. Filesystems. Examples from Linux and Windows.

Stochastic Performance Modeling (2WB60)
The focus of this course is on model-based process analysis using stochastic operations research, a discipline of mathematics that helps make better decisions in complex situations that involve randomness or uncertainty. The application areas treated in the course cover: road traffic, production processes, call centers, health centers, and computer- and communication systems. For these applications, one common issue is that random fluctuations in the offered traffic/work are a major cause of delays.
At the end of this course, you should be able to model several practical situations, study the performance of the systems at hand and make decisions on how to improve their performance. In this course, we provide a solid foundation of discrete and continuous-time Markov chains, the Poisson and renewal processes, and queuing models.

Computational Modeling (5XIE0)
Model-driven design methods are essential to guarantee the proper functioning and the required performance of embedded systems (ES) and cyber-physical systems (CPS). This course introduces models of computation that enable functional analysis, performance analysis and simulation-based evaluation techniques for ES and CPS. The course covers automata, dataflow, and stochastic models, their analysis methods, and their application to system design and synthesis.

Important Note

The ongoing revision of the Bachelor curricula as part of the introduction of Bachelor College 2.0 will impact the content and schedule of this elective package from the academic year 2024-2025 onward. The course 2WB60 Stochastic Performance Modeling will be taught for the last time in 2023-2024, with additional exam opportunities in 2024-2025. An alternative course, focusing on the development of stochastic simulation models, will be offered from 2024-2035 onward and can be taken as an alternative. The other courses will remain but their schedule (block, time slot) may change.