Syllabus for the Course «System Analysis»

Course volume: 2 ECTS (72 hours)

Semester: 2

Form of interim assessment: pass/fail exam and course project defence

Contact hours:

- lectures — 22 hours;
- seminars and practical classes — 23 hours.
  Independent study: 27 hours
  Course delivery format: AI-augmented learning (learning with intelligent assistants)

1. General Course Characteristics

The discipline “System Analysis” belongs to the professional module of the Master’s educational programme in the field 09.04.02 “Information Systems and Technologies”.

The course is delivered in the second semester of the Master’s programme and develops a systemic understanding of methods for analysing, designing and developing complex artificial systems.

Within the discipline, system analysis is considered as the initial stage of systems engineering — an engineering activity aimed at creating, implementing and developing technical and digital systems throughout their entire lifecycle.

Special attention is given to the following aspects:

- understanding the nature of complex technical and cyber-physical systems;
- methods for formulating engineering tasks and problem situations;
- analysing stakeholders and system goals;
- forming system requirements;
- developing functional structure and system architecture;
- modelling and analysing the lifecycle of engineering systems;
- assessing technological maturity of systems and technologies.

The discipline has a methodological character and develops students’ systemic engineering thinking, necessary for designing and developing modern digital systems.

The practical part of the course is built around a cross-cutting course project, where students perform a system analysis of a chosen digital or cyber-physical system.

Large Language Models (LLM) are used as a tool to support system analysis, documentation development and engineering reflection.

2. Place in the Educational Programme Structure

The discipline occupies a methodological position between courses that develop basic communication and teamwork skills and disciplines focused on development management and architectural design of digital systems.

The course builds on knowledge and skills acquired in:

- *Effective Communication in Project Activities (Soft Skills)* — develops skills in project team interaction, engineering communication and project documentation preparation.

It is studied in parallel with:

- *Project Management* — covers methods for organising and planning the development of digital systems.

Unlike the Project Management course, "System Analysis" focuses on:

- intellectual formulation of engineering tasks;
- requirement formation;
- architectural concept development.

The course uses methods of working with LLMs studied in:

- *Fundamentals of Artificial Intelligence and Large Language Models: Prompt Engineering and Context Engineering*.

Mastering this discipline creates a methodological foundation for subsequent courses:

- Information Systems Architecture;
- Cloud Information Systems Architecture;
- Distributed Systems;
- Digital Engineering Projects.

Thus, the discipline serves as a conceptual level of training that connects systemic thinking, engineering design and organisation of digital system development.

3. Learning Objectives

The objective is to develop students' systemic understanding of methods for analysing, designing and developing complex artificial systems.

Special attention is given to:

- developing systemic thinking for analysing technical and digital systems;
- mastering methods for formulating engineering tasks and problem situations;
- learning methods for analysing stakeholders and system goals;
- mastering methods for forming system requirements;
- learning functional decomposition and architectural analysis methods;
- mastering principles of systems engineering and engineering system lifecycle;
- developing skills in assessing technological maturity of systems and technologies;
- fostering skills in reasoned analysis of engineering solutions;
- developing a culture of critical use of LLM assistants in system analysis.

4. Course Tasks

Key tasks include:

- forming an understanding of the nature of complex engineering systems;
- learning system analysis and systemic thinking methods;
- mastering methods for identifying problem situations and defining system boundaries;
- learning stakeholder and user need analysis methods;
- mastering goal formulation methods;
- learning requirement formation and structuring methods;
- mastering functional decomposition methods;
- learning architectural system description principles;
- mastering system modelling methods;
- learning engineering system lifecycle;
- mastering systems engineering principles;
- learning the system lifecycle model (V-model);
- learning methods for assessing technological maturity;
- developing skills in system analysis of digital systems;
- mastering practices of using LLM in engineering analysis and system documentation preparation.

5. Expected Learning Outcomes

Upon completing the discipline, students should:

Know:

- basic concepts of system analysis;
- principles of systemic thinking;
- methods for analysing complex systems;
- structure of engineering system lifecycle;
- principles of systems engineering;
- methods for forming system requirements;
- fundamentals of architectural system description;
- principles of functional decomposition;
- models of engineering system lifecycle;
- concept of technological maturity (TRL);
- capabilities and limitations of LLM in system analysis.

Be able to:

- formulate problem situations for engineering tasks;
- define system boundaries and interactions with the environment;
- identify system stakeholders;
- formulate system goals and build a goal tree;
- develop requirement specifications;
- perform functional decomposition of a system;
- design an architectural concept of a system;
- analyse system lifecycle;
- assess technological maturity of a system;
- use LLM for engineering solution analysis.

Possess skills in:

- system analysis methods for complex systems;
- requirement structuring methods;
- architectural system analysis methods;
- preparing system documentation;
- engineering argumentation of solutions;
- critical use of LLM assistants.

6. Methodological Concept

6.1 System Analysis as the Start of Systems Engineering

System analysis is considered the initial stage of systems engineering. At this stage, problem understanding is formed, system boundaries are defined and requirements for system operation are formulated. System analysis allows transitioning from an uncertain problem situation to a formalised description of the future system.

6.2 Engineering System Lifecycle

Engineering activity is viewed as lifecycle management. The lifecycle includes:

- problem formulation;
- system design;
- component development and integration;
- system implementation;
- system operation;
- system modernisation;
- system decommissioning.

6.3 V-Model of Systems Engineering

A key element is studying the V-model of the system lifecycle:

- Left side: design stages (requirements, architectural design, component development);
- Right side: verification and integration (component testing, integration testing, system testing).

6.4 Spiral Development of Engineering Systems

Modern complex systems develop iteratively. Each new version refines requirements and improves architecture, described by the spiral development model.

6.5 Course Project as an Integrative Learning Form

A cross-cutting course project is a key element. It involves:

- selecting a digital system domain;
- describing the problem situation;
- analysing stakeholders;
- formulating system goals;
- developing requirements;
- building functional structure;
- designing architectural concept;
- modelling system lifecycle;
- assessing technological maturity.

The project integrates theoretical knowledge and practical skills in system analysis.

7. LLM Use in Education

LLMs are used as tools to support system analysis in several modes:

- LLM as a handbook — explaining system analysis and systems engineering terms;
- LLM as an analytical assistant — helping analyse domains, formulate requirements and identify architectural solutions;
- LLM as an engineering opponent — used for critical analysis of system models and architectural solutions.

Mandatory condition: engineering verification of LLM recommendations, as models may generate plausible but incorrect answers.

8. Educational Technologies

The course uses AI-augmented learning, combining traditional forms with intelligent assistants:

- lectures;
- seminars;
- practical and digital laboratory work;
- engineering discussions;
- cross-cutting course project;
- using LLM assistants for analysis and reflection.

9. Independent Study Organisation

Independent study develops system analysis and engineering thinking skills. It includes:

- analysing system analysis cases;
- preparing system models and schemes;
- completing course project stages;
- preparing analytical materials;
- working with LLM assistants with mandatory critical result verification.

CALENDAR-THEMATIC SCHEDULE

Abbreviations:

- IS — Independent Study;
- LLM — Large Language Model;
- MBSE — Model-Based Systems Engineering;
- TRL — Technology Readiness Level.

Week	Content	Lect. (h)	Sem. (h)	IS (h)
1	**Lecture:** Engineering as creation of artificial systems. Engineering is viewed as creating and developing artificial systems for solving societal problems. Special attention to engineer's role in lifecycle management and coordinating disciplines for complex solutions. Introduction to systems engineering as ensuring holistic design of complex systems. **Seminar:** Analysing examples of complex engineering systems (intelligent services, distributed digital platforms, industrial IoT systems). Students discuss system composition, functions and environment interaction. **IS:** Write an analytical essay "Why developing modern digital systems requires system analysis". **LLM use:** Terminology handbook and tool for finding complex system examples. Results verified with additional sources.	2	1	2
2	**Lecture:** Concept of a system and system boundaries. — System as a set of elements and connections	2	1	2

	forming holistic behaviour; — Role of system boundaries and environment interaction; — Introduction to systemic thinking as an approach to analysing complex objects. **Seminar:** Analysing system examples (city transport infrastructure, cloud computing platform, industrial automated system). Students identify elements, boundaries and interactions. **IS:** Select a system for the course project and prepare its initial description. **LLM use:** Model checks description completeness and generates alternative formulations.			
3	**Lecture:** Problem situation formulation. — Identifying problem situations; — Defining context of the future system; — Engineer's role in identifying problems and constraints. **Practical class:** Course project start. Students select an analysis object (digital system, service or cyber-physical system) and formulate a problem description. **IS:** Prepare section "Problem situation and system context description" for the course project. **LLM use:** Model analyses the domain and searches for similar solutions.	2	2	2
4	**Lecture:** System stakeholders. — Stakeholders: users, owners, developers, regulators; — Analysing expectations and potential conflicts of interest. **Seminar:** Building a stakeholder map for the selected system. **IS:** Prepare section "System stakeholders" for the course work. **LLM use:** Model identifies possible missing participants and analyses their interests.	2	1	2

5	**Lecture:** System goals and goal tree. — Goal formulation as a key stage of system analysis; — Hierarchical model — goal tree. **Practical class:** Building a system goal tree for the course project. **IS:** Prepare section “System goals”. **LLM use:** Model checks goal tree logic and identifies contradictions.	2	2	2
6	**Lecture:** System requirements. — Functional and non-functional requirements; — Constraints defining system properties; — Requirements as the basis for design. **Practical class:** Forming a system requirements registry. **IS:** Prepare a requirements specification. **LLM use:** Model acts as a tool for checking requirement completeness.	2	2	2
7	**Lecture:** Functional structure of a system. — Functional decomposition: describing a system through a hierarchy of functions; — Revealing system structure and key processes. **Practical class:** Building a functional system structure. **IS:** Prepare a functional system model. **LLM use:** Model generates possible system functions.	1	2	2
8	**Lecture:** System architecture. — Architecture defines component structure and interactions; — Architectural description: transition from requirements to design. **Practical class:** Developing an architectural system diagram. **IS:** Prepare section “System architecture”.	2	2	2

	LLM use: Model generates alternative architectural solutions.			
9	**Lecture:** Architectural system views. — Multiple architectural views: functional, informational, technical; — Considering a system from different perspectives. **Practical class:** Building multiple architectural views. **IS:** Expand the architectural system description. **LLM use:** Model acts as an expert tool for architecture verification.	1	2	2
10	**Lecture:** System modelling. — Methods for building system models; — Basics of model-based systems engineering (MBSE); — Analysing system structure before implementation. **Practical class:** Building a system model. **IS:** Prepare a system model. **LLM use:** Model explains elements of system models.	2	1	2
11	**Lecture:** Digital models and digital twins. — Digital model: formalised system description in a digital environment; — Digital twin: modelling system behaviour during operation. **Practical class:** Analysing applicability of a digital twin for the selected system. **IS:** Prepare course work section on the system's digital model. **LLM use:** Model searches for digital twin examples.	1	2	2
12	**Lecture:** System lifecycle. — Main stages: concept, development, implementation, operation,	2	1	2

	modernisation; — Understanding lifecycle for systems engineering. **Practical class:** Building a system lifecycle model. **IS:** Prepare system lifecycle description. **LLM use:** Model analyses lifecycle of similar systems.			
13	**Lecture:** V-model of systems engineering. — Linking design and verification stages; — Ensuring requirement traceability throughout lifecycle. **Practical class:** Analysing correspondence between requirements and system verification procedures. **IS:** Refine the system lifecycle model. **LLM use:** Model analyses correspondence between requirements and tests.	1	2	1
14	**Lecture:** Technological maturity of a system. — Technology Readiness Level (TRL) scale; — Assessing technology maturity from idea to industrial operation. **Practical class:** Evaluating system's technological maturity level. **IS:** Prepare course work section "Technological maturity assessment". **LLM use:** Model searches for similar technologies.	1	2	1
15	**Lecture:** Spiral development of engineering systems. — Iterative development: refining requirements and improving architecture; — Spiral development model. **Practical class:** Pre-defence of the course project and discussing system analysis results. **IS:** Finalising the course work. **LLM use:** Model structures the work text and checks argumentation logic.	1	2	1

16	**Course project defence.** — Presenting the system analysis results; — Demonstrating architectural concept and lifecycle model; — Justifying LLM use in the project; — Answering questions from the committee.	0	2	0