# COURSE DESCRIPTION CARD - SYLLABUS

Course name
Navigation and positioning of objects [S1MiKC2>NiPO]

## Course

Field of study
Microelectronics and Digital Communication

Year/Semester
2/4

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
full-time

Requirements
elective

## Number of hours

Lecture
15

Laboratory classes
15

Other
0

Tutorials
0

Projects/seminars
0

## Number of credit points

2,00

## Coordinators

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## Lecturers

## Prerequisites

Students should have basic knowledge of teletransmission systems, mathematics (including mathematical analysis and matrix calculus), and radio wave principles, which will facilitate their understanding of positioning and synchronization techniques in GNSS systems and local navigation systems.

## Course objective

The course aims to familiarize students with the principles of operation and applications of navigation and positioning systems, with particular emphasis on GNSS, the example of Galileo, and local location technologies using Bluetooth, UWB, and 5G/6G. Students will learn the basics of positioning methods, time synchronization, and algorithms to navigate and track objects in various environments.

## Course-related learning outcomes

Knowledge:
Knows the principles of operation of GNSS satellite navigation systems, including Galileo, and their

applications in precise positioning. (K1_W02, K1_W06)
Understands methods of locating objects in indoor and outdoor environments using Bluetooth, UWB, and 5G networks. (K1_W06, K1_W13)
Has knowledge of time synchronization and its impact on the accuracy of navigation and telecommunications systems. (K1_W02, K1_W06)

Skills:
Is able to configure and test positioning systems in various environments, assessing their accuracy and reliability. (K1_U04, K1_U09)
Is able to select the appropriate navigation method depending on the application requirements and propagation conditions. (K1_U03, K1_U13)
Is able to analyze and interpret navigation data from GNSS systems and other location technologies. (K1_U08)

Social competences:
Understands the importance of precise navigation and synchronization for the safety and reliability of telecommunications and transportation systems. (K1_K04)
Is aware of the dynamic development of location technologies and the need to constantly update knowledge in this area. (K1_K01, K1_K05)

## Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
The verification of learning outcomes is conducted through a multiple-choice test. The assessment topics, on which the questions are based, will be made available to students via the university's online learning platform. To obtain a grade of 3.0, it is necessary to earn more than half of the possible points, while the remaining grades are awarded according to the standard grading thresholds, increasing by 10% intervals.
Laboratory:
The learning outcomes are assessed through:
1. Continuous assessment - each verification of knowledge through oral answers to questions asked during laboratory exercises - weight in the final grade: 20%.
2. Reports on the exercises performed, including an analysis of the results' correctness and identification of potential problems - weight in the final grade: 30%.
3. The grade obtained from the test summarizing the exercises, checking both theoretical knowledge and practical skills - weight in the final grade: 50%.
4. Additional points for activity during laboratory classes, e.g., for initiative in solving problems related to the laboratory exercises performed.
To obtain a grade of 3.0, it is necessary to earn more than half of the possible points, while the remaining grades are awarded according to the standard grading thresholds, increasing by 10% intervals.

## Programme content

The lecture and laboratory program provides knowledge and skills related to time and frequency synchronization in ICT systems. It focuses on modern technologies used in the synchronization of Ethernet networks and 5G/6G industrial networks and includes global time distribution systems via GNSS. The laboratories provide practical experience in the measurement and implementation of synchronization, enabling students to fully understand the challenges related to these issues.

## Course topics

Lecture topics:
1. Introduction to GNSS satellite navigation (2 hours)
History of satellite navigation, basics of GNSS systems (GPS, Galileo, GLONASS, Beidou), and the structure and components of the GNSS system.
2. Galileo system: Technical details and applications (3 hours)
Structure and operation of the Galileo system, its accuracy and reliability, and applications of Galileo in precise positioning.

3. Analysis and interpretation of navigation data from GNSS systems (2 hours)
GNSS data format, data analysis techniques, and practical applications of navigation data analysis.
4. Methods of localization of objects in indoor and outdoor environments (3 hours)
Localization using Bluetooth, the UWB (Ultra-Wideband) localization technique, and 5G networks and their applications in indoor and outdoor positioning.
5. Time synchronization in navigation and telecommunications systems (2 hrs.)
The importance of time synchronization, time synchronization methods, and the impact of synchronization on system accuracy.
6. Configuration and testing of positioning systems (2 hrs.)
Positioning system configuration processes, accuracy testing and assessment methods, and examples of practical implementations.
7. Summary (1 hr.)
Summary of lectures, questions and answers, assessment of acquired knowledge
Lab topics:
Lab 1: GNSS data analysis (5 hrs.)
Acquisition and preliminary analysis of GNSS data, visualization and interpretation of results, and assessment of the accuracy and reliability of navigation data.
Lab 2: Configuration and testing of indoor positioning systems (5 hrs.)
Installation and configuration of the UWB system, testing the accuracy of the system in an indoor environment.
Lab. 3: Time synchronization in practice (5 hrs)
Implementation of time synchronization methods, testing the impact of synchronization on the accuracy of systems, and analysis and interpretation of experimental results.

## Teaching methods

Lectures:
1. Multimedia presentation: the lecturer presents the material using slides, supplemented with photos, videos, and other visual elements, real devices/measurements of synchronization systems.
2. Interactive lecture: the lecturer engages students in discussion, asks questions, and encourages them to share their thoughts, supporting a better understanding of the material and developing critical thinking skills.
3. Case study: the lecturer discusses a specific example, analyzes the problem, and proposes solutions. This allows for the application of theoretical knowledge in practice.
Laboratory:
1. Simulations: Students work with computer programs that imitate real situations.
2. Practical exercises: Students perform tasks under the lecturer's supervision, learning how to apply their knowledge in practice.
3. Group work: Students cooperate to solve problems, share knowledge, and develop communication and teamwork skills.

## Bibliography

Basic:
[1] E. D. Kaplan and C. J. Hegarty, Understanding GPS/GNSS: Principles and Applications, 3rd ed. Boston, MA, USA: Artech House, 2017.
[2] G. S. Simon and L. Sujbert, Recent Advances in Indoor Localization Systems and Technologies. Basel, Switzerland: MDPI, 2022.
[3] G. Gibbons, Galileo: The European Global Navigation Satellite System, 1st ed. London, UK: Springer, 2021.

Additional:
[4] P. Misra and P. Enge, Global Positioning System: Signals, Measurements, and Performance, 2nd ed. Lincoln, MA, USA: Ganga-Jamuna Press, 2010.

## Breakdown of average student's workload

| | Hours | ECTS |
|---|---|---|
| Total workload | 60 | 2,00 |
| Classes requiring direct contact with the teacher | 30 | 1,00 |
| Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation) | 30 | 1,00 |