Syllabus
Course Program

Programming of real-time systems

Specialty
123 – Computer Engineering

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Modern programming, mobile devices and computer games

Department
Computer Engineering and Programming (326)

Level of education
Bachelor's level

Course type
Special (professional), Mandatory

Semester
6

Language of instruction
English, Ukrainian

Lecturers and course developers

Lipchanska Oksana

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Candidate of Technical Sciences, Associate Professor of Computer Engineering and Programming department

The author and co-author of more than 30 scientific and educational methodological works. Leading lecturer in the discipline "Computer circuitry" and "Fundamentals of computational intelligence".
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Links to SCOPUS, Google Scholar profiles:
1. https://www.scopus.com/authid/detail.uri?authorId=57218516877;
2. https://scholar.google.com.ua/citations?user=nYy-w_IAAAAJ&hl=uk.
More about the lecturer on the department's website

General information

Summary

Real-time systems are specialized computer systems that must respond to external events within strictly defined time limits. They are used in situations where the timeliness of tasks is critical for the correct operation of the system. The discipline "Programming of real-time systems" covers the basics of designing, developing and implementing software for systems operating in real time. This discipline is important for students who specialize in computer science and information technology.

Course objectives and goals

The purpose of studying the discipline "Programming of real-time systems" is
- development of software for real-time systems;
- familiarization with the structural organization, basic principles of construction and operation, basic requirements and characteristics of real-time systems;

- coverage of hardware application issues, organization of interaction of hardware and software tools and related technical, conceptual and ethical problems;
- acquisition of practical skills in development, debugging and testing, use of modern software development systems for real-time systems.

Format of classes

Lectures, laboratory classes, consultations, self-study. Final control in the form of an exam.

Competencies

ФК8. Willingness to participate in the implementation of computer systems and networks, putting them into operation at objects of various purposes.
ФК14. Ability to design systems and their components considering all aspects of their life cycle and mission, including creation, configuration, operation, maintenance and disposal.

Learning outcomes

ПРН2. Have skills in conducting experiments, collecting data and modeling in computer systems.
ПРН9. Be able to apply knowledge of technical characteristics, design features, purpose and rules of operation of software and technical means of computer systems and networks to solve technical problems of the specialty.
ПРН11. Be able to search for information in various sources to solve computer engineering problems.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 32 hours, laboratory classes - 16 hours, self-study - 72 hours.

Course prerequisites

To successfully pass the course, you need to know: programming, computer electronics, computer circuitry, system programming.

Features of the course, teaching and learning methods, and technologies

When teaching the discipline "Programming of real-time systems" in lectures and laboratory classes, the following are used: story, explanation, demonstration, conversation. In lecture classes, the teaching of the material is carried out orally using presentations with an outline of the main provisions of the lecture.

Program of the course

Topics of the lectures

Topic 1.
General information about real-time systems, their classification, requirements, characteristics, construction principles.
Topic 2.
Features of development and architecture of software for real-time systems, interaction with hardware.
Topic 3.
Peculiarities of the organization, functioning and interaction of tasks in real-time systems. Peculiarities of interaction with external signals. The use of timers and the mechanism of interruptions in the processing of input signals and the formation of control signals.
Topic 4.
Means of synchronization and data exchange between individual tasks of real-time systems.
Topic 5.
Linux OS: overview, file system, command shell. Bash: command line, shell scripting. Virtual file system. Software interface. Resource.
Topic 6.

The Linux kernel: overview, structure, build, installation. Kernel modules: loading, uninstalling, dependencies, diagnostics, debugging.

Topics of the workshops

Topics of the laboratory classes

Topic 1. Introduction to the STM32CubeIDE integrated development environment.
Topic 2. Introduction to the special training tool GlobalLogic Embedded Starter Kit.
Topic 3. Introduction to the FreeRTOS real-time operating system.
Topic 4. Application of means of interprocessor interaction in FreeRTOS.
Topic 5. Bash: command line, shell scripting.
Topic 6. Programming in the C language for the Linux OS.
Topic 7. Kernel modules: loading, uninstallation.
Topic 8. Virtual file system. Software interface.

Self-study

The student's independent work is reduced to studying lecture material, preparing for laboratory classes using methodical recommendations, and completing an individual task.
The result is documented in a written report in the form of a presentation of the developed software.
Students are also recommended additional materials (videos, articles, textbooks) for independent processing and analysis, preparation for lectures and laboratory classes.
Materials for self-study are available on the website.

Course materials and recommended reading

Compulsory materials:

1. Amos Brian. Hands-On RTOS with Microcontrollers: Building real-time embedded systems using FreeRTOS, STM32 MCUs, and SEGGER debug tools – Packt Publishing Ltd., 2020. – 496 p.
2. Cooling J. Real-time Operating Systems. Book 1. The Foundations – Lindentree Associates, 2018. – 253 p.
3. Laplante P.A. Real Time System Design and Analysis. 3rd Edition. – IEEE Press/Wiley Interscience, 2004 - 530 p.
4. Lee E.A., Seshia S.A. Introduction to Embedded Systems - A Cyber-Physical Systems Approach - Second Edition. – MIT Press, 2017. - 564 p.
5. Shyamasundar R.K., Ramesh S. Real Time Programming: Languages, Specification and Verification – World Scientific Publishing, 2010. - 262 p.
6. Walls Colin. Embedded RTOS Design: Insights and Implementation –
Newnes, 2021. - 382 p.

Additional materials:

7. Cooling J. Real-time Operating Systems. Book 2. The Practice – Lindentree Associates, 2018. –216 p.
8. Leigh A.W. Real Time Software For Small Systems – New York : John Wiley and Sons, 1988. - 184 p.

Assessment and grading

Criteria for assessment of student performance, and the final score structure

100% of the final grade consists of the results of the assessment in the form of credit (20%) and current assessment (80%).
Assessment: oral report (2 questions on theory).
Current assessment: 2 online tests (40%), laboratory work (40%).

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	April, 22, 2024	Head of the department Oleksandr ZAKOVOROTNYI
	April, 22, 2024	Guarantor of the educational program Mykola ZAPOLOVSKYI