Syllabus
Course Program

Blockchain Technology

Specialty
113 Applied mathematics

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Intelligent Data Analysis

Department
Computer Mathematics and Data Analysis

Level of education
Master's level

Discipline type
Special (professional), Selective

Semester
2

Language of instruction
Ukrainian, English

Lecturers and course developers

Maksym Tatariants

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Assistant of the Department of Computer Mathematics and Data Analysis

Work experience - 5 years. Leading lecturer in the disciplines: "Blockchain technology", "Machine learning operations"

More about the lecturer on the website

General information

Summary

This course provides an in-depth exploration of cryptocurrency and blockchain technology. It covers the fundamental principles, mechanics, and applications of various blockchain systems, including Bitcoin, Ethereum, and advanced cryptographic techniques such as zk-SNARKs. Students will gain practical experience through laboratory classes focused on key aspects of blockchain technology, including hashing functions, proof-of-work mechanisms, and building blockchain applications. The course aims to equip students with both theoretical knowledge and practical skills essential for understanding and working within the cryptocurrency and blockchain domains.

Course objectives and goals

The purpose of this course is to develop a comprehensive understanding of cryptocurrency and blockchain technology. Students will explore the core principles of blockchain systems, including consensus mechanisms, smart contracts, and cryptographic security.

Format of classes

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

Competencies

GC 1. The ability to understand and apply key concepts in cryptocurrency and blockchain technology.
GC 2. The ability to develop and manage blockchain-based applications and systems.
GC 3. The ability to critically evaluate and apply cryptographic techniques for ensuring security and privacy.

GC 4. The ability to analyze and solve problems related to blockchain scalability and interoperability.
GC 5. The ability to keep abreast of emerging trends and technologies in the blockchain and cryptocurrency fields.
SC 1. The ability to formulate and analyze complex problems related to blockchain technology.
SC 2. The ability to develop and apply cryptographic and consensus algorithms in blockchain systems.
SC 3. The ability to design, implement, and optimize blockchain-based applications and smart contracts.
SC 4. The ability to evaluate and address issues related to blockchain scalability, privacy, and cross-chain compatibility.
SC 5. The ability to conduct hands-on experimentation and development with blockchain technologies.

Learning outcomes

LO 1. Demonstrate a thorough understanding of blockchain fundamentals, including cryptographic principles, consensus mechanisms, and smart contract development.
LO 2. Be able to design, implement, and manage blockchain-based systems and applications, with a focus on major cryptocurrencies and decentralized platforms.
LO 3. Possess practical skills in developing with blockchain technologies, including hashing functions, proof-of-work mechanisms, and tokenization.
LO 4. Understand and apply advanced concepts such as zk-SNARKs, privacy-enhancing technologies, and scalability solutions like rollups.
LO 5. Be able to critically analyze and address challenges related to blockchain privacy, security, and cross-chain interoperability.
LO 6. Develop the capability to implement and manage a private blockchain network and explore emerging trends in the cryptocurrency and blockchain space.

Student workload

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

Course prerequisites

This course does not require prerequisites.

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

Python programming skills are required. Study materials are available to students on the teacher's website.

Program of the course

Topics of the lectures

Topic 1. Introduction to the cryptocurrency and cryprography.
Topic 2. Fundamentals and Mechanics of Bitcoin.
Topic 3. Wallets: Safeguarding and Managing Cryptocurrency Assets.
Topic 4. Traditional Consensus: Network Architectures and Characteristics of Secure State Machine Replication (SMR).
Topic 5. Responsibility and Rewards in Consensus Mechanisms: Proof-of-Stake.
Topic 6. Ethereum: Decentralized Applications, the Ethereum Virtual Machine (EVM), and the Ethereum Blockchain.
Topic 7. Developing with Solidity.
Topic 8. Stablecoins and Lending Mechanisms.
Topic 9. Decentralized exchanges.
Topic 10. Maximal Extractable Value (MEV) and NFT Trading Platforms.
Topic 11. Privacy: Blockchain De-anonymization and Transaction Mixing.
Topic 12. zk-SNARKs and their applications.
Topic 13. Building a preprocessing zk-SNARK.

Topic 14. Expanding Blockchain Capacity: Payment Channels and State Channels.
Topic 15. Enhancing Blockchain Scalability with Rollups: Optimistic and Zero-Knowledge.
Topic 16. Account Abstraction, Cross-Chain Compatibility, and Governance.

Topics of the laboratory classes

Topic 1. Hashing Functions in Blockchain Technologies.
Topic 2. Proof of Work in Bitcoin.
Topic 3. Building a blockchain demo with Python.
Topic 4. Tokenization and NFTs.
Topic 5. Setting Up a Private Blockchain Network.

Self-study

During self-stury, students study lecture material, prepare for tests, and exams.

Non-formal education

In non-formal education according to the relevant Regulation (http://surl.li/pxssv), the educational component or its individual topics can be taken into account in case of independent completion of professional courses/trainings, obtaining civic education, online education, professional internship, etc.

In particular, individual topics of this component may be taken into account upon successful completion of the following courses:

https://github.com/smartcontractkit/full-blockchain-solidity-course-py

Course materials and recommended reading

Main literature

1. Andreas M. Antonopoulos. *Mastering Bitcoin: Unlocking Digital Cryptocurrencies*. O'Reilly Media, Inc. – 2014. – ISBN: 9781491902639.

2. Vitalik Buterin. *Mastering Ethereum: Building Smart Contracts and DApps*. O'Reilly Media, Inc. – 2018. – ISBN: 9781491971940.

3. Narayan Prusty. *Blockchain Basics: A Non-Technical Introduction in 25 Steps*. Apress – 2016. – ISBN: 9781484226032.

4. Nakamoto, Satoshi. *Bitcoin: A Peer-to-Peer Electronic Cash System*. Available online: https://bitcoin.org/bitcoin.pdf

5. Blockchain Technology Explained: The Ultimate Guide to Understanding Blockchain, Cryptocurrency, and the Future of Financial Transactions. Available online: https://www.ibm.com/topics/what-is-blockchain

6. Ethereum White Paper. Available online: https://ethereum.org/en/whitepaper/

7. A Beginner's Guide to zk-SNARKs. Available online: https://appinventivinsider.medium.com/a-beginners-guide-to-zk-snarks-6e2eb237f71e

8. CoinDesk's Blockchain 101. Available online: https://www.coindesk.com/learn/2020/01/03/blockchain-101/

Additional literature

9. "The Basics of Bitcoins and Blockchains" by Antony Lewis. 2018. – ISBN: 9781948080454.

10. "Blockchain Basics" by Daniel Drescher. 2017. – ISBN: 9781484226032.

11. "Blockchain and the Law: The Rule of Code" by Primavera De Filippi and Aaron Wright. 2018. – ISBN: 9780674976428.

12. "Mastering Bitcoin: Programming the Open Blockchain" by Andreas M. Antonopoulos. 2017. Available online: https://aantonop.com/books/
13. "Introduction to Blockchain Technology" video series by Simply Explained. Available online: https://www.youtube.com/watch?v=SSo_EIwHSd4&ab_channel=SimplyExplained
14. "A Comprehensive Introduction to Ethereum" by Alex Tapscott. Available online: https://www.forbes.com/sites/alextapscott/2020/05/21/a-comprehensive-introduction-to-ethereum/?sh=4d2e0a0f509f
15. "Decentralized Finance (DeFi): The Future of Financial Services" white paper. Available online: https://www.coindesk.com/learn/what-is-defi/

Assessment and grading

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

A necessary condition for passing the test or exam is the completion of laboratory work.
30 points are awarded for writing control tests.
Passing laboratory tests - 30 points.
Exam – 40 points.

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	Date, signature 31.08.2024		Head of the department Olena AKHIIEZER
	Date, signature 31.08.2023		Guarantor of the educational program Leonid LYUBCHYK