COURSE DESCRIPTION

1. Program information

1.1 University	**Alexandru Ioan Cuza University of Iaşi**
1.2 Faculty	**Faculty of Computer Science**
1.3 Department	**Department of Computer Science**
1.4 Study domain	**Computer Science**
1.5 Study cycle	**Master**
1.6 Study program / Qualification	**Masters in Informatics (Distributed systems / Software engineering / Artificial Intelligence and Optimization / Information Security)**

2. Course Information

2.1 Course name			**Blockchain: Foundations and Applications**				
2.2 Course teacher			**Assoc. Prof. Emanuel Onica, Assoc. Prof. Andrei Arusoaie**				
2.3 Seminar teacher			**Assoc. Prof. Emanuel Onica, Assoc. Prof. Andrei Arusoaie**				
2.4 Year of study	**1/2**	**2.5** Semester	**1**	**2.6** Evaluation type	**E**	**2.7** Discipline status*	**OP**

** OB – Mandatory / OP – Optional*

3. Total estimated hours (hours per semester and didactic activities)

3.1 Hours per week	**4**	In which: **3.2** course	**2**	**3.3** seminar/laboratory	**2**
3.4 Hours in curriculum	**56**	In which: **3.5** course	**28**	**3.6** seminar/laboratory	**28**

Time distribution	hours
Manual study, course support, bibliography, and others	**25**
Suplementary documentation in the library, electronic forums, and on the field	**25**
Seminaries/laboratories preparation, homeworks, reports, portfolios, and essays	**50**
Tutoring	**0**
Evaluation	**4**
Other activities	**0**

3.7 Total hours individual study	**100**
3.8 Total hours per semester	**160**
3.9 Credits	**7.5**

4. Preconditions (if necessary)

4.1 Curriculum	**Object-Oriented Programming, Web Technologies, Computer Networks, Information Security, Algorithmics**
4.2 Competencies	**Good programming skills**

5. Conditions (if necessary)

5.1 For course operation	The course will mainly take place in physical format (face-to-face). Online operation will be partially considered depending on opportunity, necessity and specific means availability, and will not account for more than a maximum of 29% of the total course time.
5.2 For seminary/laboratory operation	The laboratory will mainly take place in physical format (face-to-face). Online operation will be partially considered depending on opportunity, necessity and specific means availability, and will not account for more than a maximum of 29% of the total laboratory time.

6. Specific skills acquired

Professional skills	**C1.** Create Smart Contracts in Ethereum **C2.** Implement decentralized applications on top of a blockchain platform
Transversal skills	**CT1.** The ability to design and implement a smart contract **CT2.** The ability to model real-life contracts as smart contracts **CT3.** The ability to operate with cryptocurrencies **CT4.** Understanding of consensus in blockchain environments

7. Course objectives

7.1 General objective	The main objective is to introduce the blockchain technology to students.
7.2 Specific objectives	After taking this course, students will be able to : ▪ Explain the specific concepts of the blockchain: blocks, transactions, hash functions, mining, consensus and consensus algorithms (Proof-of-work, Proof-of-stake, Proof-of-space-time, Proof-of-authority), wallets, peer-to-peer networks, public key cryptography ▪ Design and implement a smart contract ▪ Use at least one blockchain platform (Ethereum)

8. Contents

8.1	**Lecture**	**Teaching methods**	**Observations** (hours and bibliography)
1.	Blockchain: Introduction. Concept. Platforms: Bitcoin, Ethereum, and others. Applications.	Slides, blackboard	2 hours
2.	Ethereum: accounts, smart contracts (the basics), transactions, fees, nodes and networks.	Slides, blackboard	2 hours
3.	Smart contracts: Solidity.	Slides, blackboard	2 hours
4.	Smart contracts: Examples. ERC Standards.	Slides, blackboard	2 hours
5.	Design patterns in Solidity.	Slides, blackboard	2 hours
6.	Decentralized applications: case studies. (*)	Slides, blackboard	2 hours

7.	Bitcoin: the Bitcoin network. Keys. Addresses. Wallets. Transactions. (*)	Slides, blackboard	2 hours
8.	Recap and consolidation of primary notions.	Recapitulative discussions	2 hours
9.	Bitcoin: advanced aspects. Blocks. Mining.	Slides, blackboard	2 hours
10.	Bitcoin: advanced aspects. Bitcoin-Ethereum interactions. Smart contracts in Bitcoin.	Slides, blackboard	2 hours
11	Security in Ethereum.	Slides, blackboard	2 hours
12.	Consensus algorithms I. General Introduction for consensus in distributed systems. Paxos. Raft.	Slides, blackboard	2 hours
13.	Consensus algorithms II. Practical Byzantine Fault Tolerance. Proof of work. Proof of stake. Proof of space-time. Proof of authority. (*)	Slides, blackboard	2 hours
14.	Ethereum – advanced notions: The Whisper protocol, Swarm. Other blockchain platforms: Hyperledger Fabric. Cryptocurrencies. (*)	Slides, blackboard	2 hours

Bibliography

[1] Blockchain Applications: A Hands-On Approach (A. Bahga, V. Madisetti) – VPT Publishing House, 2017
[2] Mastering Bitcoin: Programming the Open Blockchain (A. M. Antonopoulos) – O’Reilly Media, 2017
[3] Practical Byzantine Fault Tolerance (M. Castro, B. Liskov) - Proceedings of the Third Symposium on Operating Systems Design and Implementation, USENIX OSDI 1999
[4] Hyperledger Fabric: A Distributed Operating System for Permissioned Blockchains (E. Androulaki et al.) – Proceedings of the ACM EuroSys 2018 Conference

8.2	**Seminar / Laboratory**	**Teaching methods**	**Observations** (hours and bibliography)
1.	Ethereum clients and wallets. Setup: installing tools for Ethereum.	Introductory discussions.	2 hours
2.	Ethereum nodes: Geth. Demo lab.	Introductory discussions.	2 hours
3.	Solidity: development and testing of the first smart contract.	Exercises proposal and discussions.	2 hours
4.	Solidity: smart contracts – inheritance, interfaces, testing. Homework description.	Exercises proposal and discussions.	2 hours
5.	Solidity: smart contracts - design patterns.	Exercises proposal and discussions.	2 hours
6.	Decentralized applications – introduction and examples. Guest speaker with expertise in web development. (*)	Exercises proposal and discussions.	2 hours
7.	Homework verification. (*)	Direct discussions.	2 hours

8.	Recap discussions. Presentation of research articles in the blockchain technical field.	Free discussions. Evaluation.	2 hours
9.	Tokens. Presentation of research articles in the blockchain technical field.	Exercises proposal and discussions. Evaluation.	2 hours
10.	Security in smart contracts and DApps. Presentation of research articles in the blockchain technical field.	Free discussions. Evaluation.	2 hours
11.	Presentation of research articles in the blockchain technical field. Homework descripiton. Advanced aspects: confidentiality in contracts.	Free discussions. Evaluation.	2 hours
12.	Presentation of research articles in the blockchain technical field. Advanced aspects: Ethereum in desktop or enterprise applications.	Free discussions. Evaluation.	2 hours
13.	Presentation of research articles in the blockchain technical field. (*)	Free discussions. Evaluation.	2 hours
14.	Homework verification. (*)	Direct discussions.	2 hours

Bibliography

[1] Blockchain Applications: A Hands-On Approach (A. Bahga, V. Madisetti) – VPT Publishing House, 2017
[2] Solidity Programming Essentials: A beginner's guide to build smart contracts for Ethereum and blockchain (R. Modi) – Packt Publishing, 2018

(*) Activities marked in this manner can take place online, according to conditions mentioned at point 5, using specific methods assisted by technology.

9. Course content synchronization with the expectations of the community representatives, professional associations and employers from the program domain

This discipline aims to develop the ability to understand and use a blockchain platform. Blockchain platforms and in particular decentralized applications received lately increased attention from the industry. Multiple distributed frameworks, especially in the financial technology area currently try to adopt the blockchain model. Therefore, the technical topics discussed by the course are of high interest especially in the current context of enterprise software industry environment.

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 The weigth of each evaluation form (%)
10.1 Course	- understanding of the blockchain architecture concepts, both in general and in particular for the Ethereum and Bitcoin platforms - understanding of development paradigms	Written exam	45%

	- capacity to identify and address various scalability, consensus, and security issues in blockchain - quality of stating the answers		
10.2 Laboratory	- the capacity to program smart contracts and applications for the Ethereum blockchain platform - reading and summarizing the relevant information in various publications of the scientific field - the quality of proposed implementations	Research paper presentations (25% - part of ongoing evaluation during semester) Presentation of practical homeworks (30% - part of ongoing evaluation during semester)	55%
10.3 Minimal performance standards			
For the theoretical side the fulfillment of the minimal conditions implies the understanding of the basic theoretical notions regarding the blockchain architecture. For the practical side the fulfillment of the minimal conditions implies correct and complete implementation of homeworks according to given specifications that imply integration of smart contracts over the Ethereum platform. The minimal passing grade criteria is fulfilling the minimal conditions described above, which corresponds to acummulating a minimum of 45% of the total aggregated maximum points.			

Date, 23.09.2022	Course teacher, Emanuel Onica, Andrei Arusoaie	Seminary teacher, Emanuel Onica

Date of approval in department, Director of department,