Blockchain Technology and Applications

Course Level: No blockchain knowledge required.
Hardware requirement: Accessibility (preferably through an individual laptop) to the Internet with reasonable speed and ability to install plugins and interact with blockchain decentralized applications.

Reference book 1: Blockchain, Cryptocurrency and Decentralized Finance, B. Ramamurthy (co-author), World Scientific Publishing, 2025. ISBN: ISBN: 978-981-12-5571-7

Reference book 2: B. Ramamurthy. Blockchain in Action. Manning publishers, 2020. ISBN: 978-1617296338

Duration: 6 sessions with 6X45 lectures each session: Oct13, 14, Oct 27, 28, and Jan 12.

Course Overview

This course introduces students to blockchain technology and prepares them to develop and interact with blockchain applications. Beginning with blockchain's role as a decentralized trust infrastructure, students explore blockchain architecture and operations. The course then covers cryptographic foundations and security considerations essential for blockchain systems. Students learn to program smart contracts and develop these skills into complete decentralized application development. The final modules focus on tokenization and digital asset management, equipping students with practical skills for real-world blockchain development. Throughout the course, students will implement concepts using an Ethereum testnet, gaining hands-on experience with live blockchain environments.

All hands-on activities will be instructed by detailed instructions in a handout and will be demonstrated and guided by the instructor.

Course Structure

Session 1:

Introducing the students and the teacher. Overview of the structure of the course.

Blockchain Fundamentals

Students will explore core blockchain concepts including:

- What is a blockchain?
- Bitcoin ad its whitepaper: https://bitcoin.org/bitcoin.pdf
- Bitcoin genesis block: : Genesis Block Explorer
- Definition and structure of blockchain through transactions, blocks, and chain architecture
- The three D's: Distributed Ledger, Disintermediation, Decentralization
- Decentralized identity systems and wallet technology
- Hands-on activity: MetaMask Wallet installation: MetaMask.io

Session 2: Cryptography Foundations

This session will explain the operational details:

- Peer-to-peer transactions
- Public/Private key cryptography (256-bit)
- Digital signatures and hashing algorithms
- Consensus mechanisms and their role in network security
- Practical examination of distributed immutable ledger using Ethereum networks
- Proof of Work (PoW) - Bitcoin's mining; Proof of Stake (PoS) - Ethereum's evolution
- Hands-on activity: Introduction to testnet, collect test cryptocurrency and transact

Session 3: Smart Contract – The control center

This section introduces programmable blockchain functionality:

- Code execution on blockchain networks
- Smart contract structure and elements: Counter smart contract example
- Coding rules and policies in smart contracts
- Solidity programming language fundamentals
- Smart contract: Best practices
- Remix Integrated Development Environment (IDE)
- Hands-on activity: Counter smart contract on Remix: Smart contract compilation, deployment, and testing using the Ethereum blockchain environment

Session 4: Decentralized Applications

The session integrates concepts into full stack decentralized applications:

- Decentralized Application (DApp) architecture and stack design
- User interface for blockchain applications
- Web3 evolution
- Offchain and onchain data
- Decentralized Finance (DeFi) use cases
- DAO and governance
- Hands-on activity 1: Digital democracy smart contract and decentralized application (DApp)
- Hands-on activity 2: Blind Auction interaction

Session 5: Tokenization and Digital Assets

- Ethereum standards process
- Fungible tokens (FT) – ERC-20
- Non-Fungible tokens (NFT) – ERC-721
- Digital assets and real-world assets
- Oracles and external data delivery
- Hands-on activity 1: Deploy and interact with FT (ERC-20)
- Hands-on activity 2: Deploy and interact with an NFT (RWA)

Learning Objectives

Upon successful completion of this course, students will be able to:

- Explain blockchain technology's fundamental principles and its function as decentralized trust infrastructure
- Apply cryptographic principles essential to blockchain security, including hashing, digital signatures, and consensus mechanisms
- Design smart contracts that follow established patterns and security standards
- Implement user interaction patterns specific to blockchain applications, including wallet integration and transaction handling
- Design and implement token systems for various use cases (utility tokens, governance tokens, NFTs)

Current Industry Focus

This course emphasizes Ethereum-based networks, exploring new paradigms for decentralized systems such as smart contracts, tokenization and digital assets to enable broader participation in the digital economy.

Course Outcomes

On completion of the course, learners will possess both theoretical understanding and practical usage of blockchain technology, positioning them to contribute to the evolving landscape of decentralized applications and cryptocurrency ecosystems.

Assessment: Major part of the assessment is by participation in class activity.